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(54) **COMPRESSED SELF-IGNITION GASOLINE ENGINE**

(57) Abstract

PROBLEM TO BE SOLVED: To suppress occurrence of instable combustion or knocking in a low load operation area, at the changeover time between spark ignition combustion operation and compressed self-ignition combustion operation.

SOLUTION: A uniform spark ignition combustion operation state under extremely low load is changed over with a uniform compressed self-ignition combustion state under appropriately low load, and vise versa. A closed timing is provided at the changeover time, where both an intake and an exhaust valves are closed near a compression top dead center by means of a variable opening/ closing time means. The compressed self-ignition combustion is started after performing the spark ignition combustion under a stratified charge state in which fuel injection is performed during compression stroke. In the compressed self-ignition combustion, fuel injection is first performed during the closed timing.

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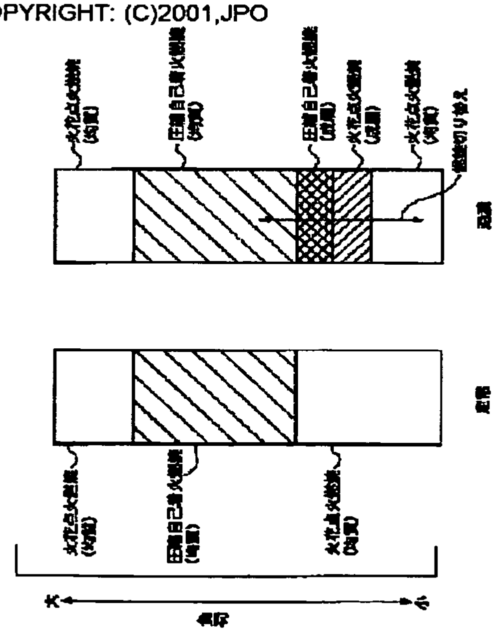

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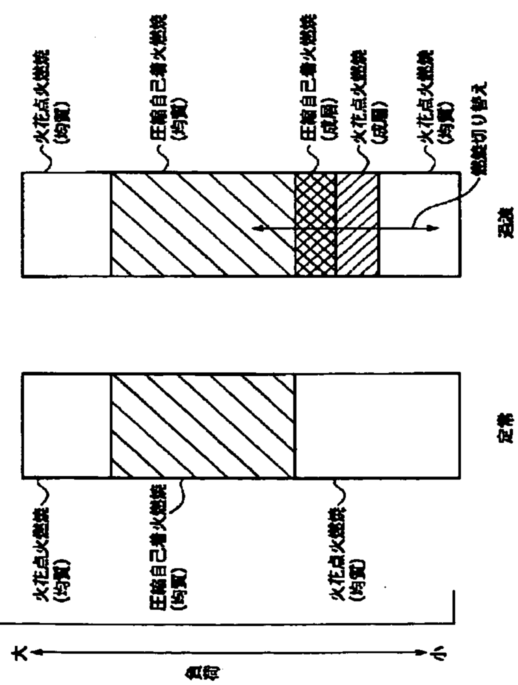
(54)【発明の名称】　圧縮自己着火式ガソリン機関

(57)【要約】　　(修正有)

【課題】　低負荷運転領域において、火花点火燃焼運転と圧縮自己着火燃焼運転との相互切替時に、燃焼不安定あるいはノッキングの発生を抑制する。

【解決手段】　極低負荷の均質火花点火燃焼運転状態と中低負荷の均質圧縮自己着火燃焼運転状態との相互の切換時に、開閉時期可変手段により圧縮上死点付近で吸排気弁が共に閉じた密閉期間を設け、圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行った後に、圧縮自己着火燃焼を開始し、圧縮自己着火燃焼は、まず密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行う



【特許請求の範囲】

【請求項１】　燃焼室内に直接燃料を噴射する筒内噴射弁を備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、
火花点火燃焼運転から圧縮自己着火燃焼運転に燃焼切り替えを行う際に、火花点火燃焼は圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行った後に、圧縮自己着火燃焼を開始することを特徴とする圧縮自己着火式ガソリン機関。

【請求項２】　圧縮自己着火燃焼運転から火花点火燃焼運転に燃焼切り替えを行う際に、火花点火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行うことを特徴とする請求項１記載の圧縮自己着火式ガソリン機関。

【請求項３】　燃焼室内に直接燃料を噴射する筒内噴射弁を備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、
火花点火燃焼運転から圧縮自己着火燃焼運転に燃焼切り替えを行う際に、圧縮自己着火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行うことを特徴とする圧縮自己着火式ガソリン機関。

【請求項４】　圧縮自己着火燃焼運転から火花点火燃焼運転に燃焼切り替えを行う際に、圧縮自己着火燃焼時に圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行った後に火花点火燃焼を行うことを特徴とする請求項３記載の圧縮自己着火式ガソリン機関。

【請求項５】　燃焼室内に直接燃料を噴射する筒内噴射弁と吸排気弁の開閉時期を変更する開閉時期可変手段とを備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、
火花点火燃焼から圧縮自己着火燃焼に切り替える際に、前記開閉時期可変手段により圧縮上死点付近で吸排気弁が共に閉じた密閉期間を設け、圧縮自己着火燃焼はまず前記密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行うことを特徴とする圧縮自己着火式ガソリン機関。

【請求項６】　圧縮自己着火燃焼から火花点火燃焼に切り替える際に、前記密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行った後に火花点火燃焼を行うことを特徴とする請求項５に記載の圧縮自己着火式ガソリン機関。

【請求項７】　燃焼室内に直接燃料を噴射する筒内噴射弁を備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、
火花点火燃焼運転から圧縮自己着火燃焼運転に燃焼切り替えを行う際に、火花点火燃焼は圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行った後に、圧縮自己着火燃焼を開始し、圧縮自己着火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行うことを特徴とする圧縮自己着火式ガソリン機関。

【請求項８】　圧縮自己着火燃焼運転から圧縮自己着火燃焼運転に燃焼切り替えを行う際に、圧縮自己着火燃焼は圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行った後に、火花点火燃焼を開始し、火花点火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行うことを特徴とする請求項７に記載の圧縮自己着火式ガソリン機関。

【請求項９】　燃焼室内に直接燃料を噴射する筒内噴射弁と吸排気弁の開閉時期を変更する開閉時期可変手段とを備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、
火花点火燃焼から圧縮自己着火燃焼に切り替える際に、前記開閉時期可変手段により圧縮上死点付近で吸排気弁が共に閉じた密閉期間を設け、圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行った後に、圧縮自己着火燃焼を開始し、圧縮自己着火燃焼は、まず前記密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行うことを特徴とする圧縮自己着火式ガソリン機関。

【請求項１０】　圧縮自己着火燃焼から火花点火燃焼に切り替える際に、圧縮自己着火燃焼は、前記密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行った後に、火花点火燃焼を行い、火花点火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行うことを特徴とする請求項９記載の圧縮自己着火式ガソリン機関。

【請求項１１】　前記火花点火燃焼から圧縮自己着火燃焼への切り替え直前の点火タイミングは、同一機関回転数及び同一負荷条件における定常状態の点火タイミングに対して遅角させることを特徴とする請求項１，３，５，７，９のいずれか１項に記載の圧縮自己着火式ガソリン機関。

【請求項１２】　前記火花点火燃焼から圧縮自己着火燃焼へ切り替え後、圧縮上死点前３０°付近で点火プラグに放電して圧縮自己着火を促進し、圧縮自己着火燃焼の開始後に火花点火を停止することを特徴とする請求項１１に記載の圧縮自己着火式ガソリン機関。

【請求項１３】　前記火花点火燃焼から圧縮自己着火燃焼への切り替え時に、燃料の一部にのみを前記密閉期間中に噴射するとともに、燃料の残部を機関の負荷に応じて、圧縮行程中または吸気行程中に噴射することを特徴とする請求項５または請求項９に記載の圧縮自己着火式ガソリン機関。

【請求項１４】　前記火花点火燃焼から圧縮自己着火燃焼への切り替え時に、前記密閉期間中に噴射する燃料量を、通常の圧縮自己着火燃焼時に対して増量したことを特徴とする請求項１３に記載の圧縮自己着火式ガソリン機関。

【請求項１５】　前記火花点火燃焼から圧縮自己着火燃

焼への切り替え時に、前記密閉期間の長さを燃焼切り替え時の負荷に応じて低負荷側は略一定とし、所定の負荷を超えたところから負荷の増加に応じて前記密閉期間の長さを減少させることを特徴とする請求項５，９，１１，１２，１３，１４のいずれか１項に記載の圧縮自己着火式ガソリン機関。

【請求項１６】　前記火花点火燃焼から圧縮自己着火燃焼への切り替え時に、燃焼切り替えを行う気筒を少なくとも２つ以上のグループに分けて、グループ間で時間をずらして順次燃焼の切り替えを行うことを特徴とする請求項１ないし請求項１５のいずれか１項記載の圧縮自己着火式ガソリン機関。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、運転条件によって火花点火燃焼と圧縮自己着火燃焼とを動的に切り替える圧縮自己着火式ガソリン機関に関する。

【０００２】

【従来の技術】圧縮自己着火燃焼は燃焼室の多点で燃焼が開始されるため燃焼速度が速く、通常の火花点火燃焼に比べて空燃比がリーンな状態でも安定した燃焼を実現することができて燃料消費率の向上が可能であり、また空燃比がリーンなため燃焼温度が低下することから、排気ガス中のNOxを大幅に低減することもできる。また燃料と空気を十分に予混合しておけば、空燃比がより均一となり、更にNOx を低減することができる。

【０００３】また、高回転、高負荷領域では通常の火花点火燃焼を行わせ、低回転、低中負荷領域では火花点火燃焼から圧縮自己着火燃焼に燃焼形態を切り替えることによって、高回転、高負荷時の高出力確保と、低回転、低中負荷時の燃料消費率向上、ＮOxの低減化の両立を図ることができる。

【０００４】しかしながら、圧縮自己着火燃焼が可能となるような混合気の温度、圧力を達成するために、機関のベース圧縮比を上げる場合では、火花点火燃焼時にノッキングが発生する。ノッキングを回避するために、吸入空気量を低下させるか点火時期の遅角化を行うと、比出力の低下が避けられないという問題が生じる。

【０００５】そこで機関のベース圧縮比を過度に上げずに圧縮自己着火燃焼を実現させる方法として、圧縮自己着火燃焼時には排気ＴＤＣ付近で吸排気弁が共に閉となり燃焼室を密閉する密閉期間を設けることで内部ＥＧＲにより吸気加熱を行う方法が提案されている（例えば、特開平１０－２５２５１２号公報）。

【０００６】しかしながら従来技術はすべての運転領域を圧縮自己着火運転することを前提としており、火花点火燃焼運転と圧縮自己着火燃焼運転との機関運転中の動的な切り替えについては言及されていない。

【０００７】また、吸排気弁の開閉時期又はリフト量を切り替える従来技術としては、カムシャフトにプロフィールの異なる複数のカムを備え、それぞれのカムに対向するロッカーアームの係合レバーの状態を油圧駆動ピストンで切り替える機械式可変動弁機構が知られている（例えば、特開平９－２０３３０７号公報）。

【０００８】この機械式可変動弁機構によれば、油圧制御弁の操作から異なるロッカーアームへの切り替えが終了するまでに燃焼サイクルで数サイクル要していた。

【０００９】

【発明が解決しようとする課題】自己ＥＧＲによる吸気加熱により圧縮自己着火燃焼を発生させる場合には、最後の火花点火燃焼サイクルに次ぐ燃焼サイクルでは、自己ＥＧＲ量を所定量増加させ圧縮自己着火燃焼を確実に発生させなければならない。もし次の燃焼サイクルにおいて圧縮自己着火燃焼が不十分であれば、筒内温度及び圧力が低下し、さらに圧縮自己着火が困難となる。

【００１０】しかしながら、従来の機械式可変動弁機構の応答性では、圧縮自己着火燃焼で要求される自己ＥＧＲ量への変換には数サイクルを要してしまうため、燃焼切り替え前に予め自己ＥＧＲ量を増加させた場合には火花点火燃焼でノッキングが発生するという問題点があった。

【００１１】反対に自己ＥＧＲ量の増加が後れた場合には、圧縮自己着火燃焼が不安定となり自己ＥＧＲによる熱量が少なくなるため、安定した圧縮自己着火燃焼の復帰が困難であるという問題点があった。

【００１２】また、逆に圧縮自己着火燃焼から火花点火燃焼への切り替えに際しては、自己ＥＧＲ量が多い場合には、筒内温度が高くなり、火花点火燃焼時にノッキングが発生するという問題点があった。

【００１３】反対に火花点火燃焼時のノッキングを防止するために、予め自己ＥＧＲ量を低減させた場合には、切り替え前の圧縮自己着火燃焼が不安定になるという問題点があった。

【００１４】前記問題点に加えて、火花点火燃焼運転と圧縮自己着火燃焼運転の切り替えでは複数の運転条件によって行われ、条件によっては吸入負圧を変更する場合もある。この場合に、圧力の変更にも応答遅れがあるため、その設定には数サイクル要することになる。

【００１５】従って、火花点火燃焼運転から圧縮自己着火燃焼運転への切り替えに際しては、筒内圧力が低いため、圧縮自己着火燃焼が不安定となる。また、逆に圧縮自己着火燃焼から火花点火燃焼への切り替えに際しては、筒内圧力が高いために、火花点火燃焼時にノッキングが発生するという問題点があった。

【００１６】また、前述したように火花点火燃焼運転と圧縮自己着火燃焼運転の切り替えは、複数の運転条件で行われるため、各切り替え条件に適した制御を行わないと燃焼不安定およびノッキングが発生するという問題点があった。

【００１７】本発明はかかる問題点に鑑みたもので、そ

の目的は、低負荷運転領域において、火花点火燃焼運転から圧縮自己着火燃焼運転への切り替え時あるいは圧縮自己着火燃焼運転から火花点火燃焼運転への切り替え時に、燃焼不安定あるいはノッキングの発生を抑制しつつ、安定した切り替えができる圧縮自己着火式ガソリン機関を提供することにある。

【００１８】また本発明は、応答性が必ずしも高くない機械式可変動弁機構を用いた場合においても、ノッキングの発生を抑止しつつ、安定した圧縮自己着火燃焼への切り替えができる圧縮自己着火式ガソリン機関を提供することにある。

【００１９】

【課題を解決するための手段】請求項１記載の発明は、上記課題を解決するために、燃焼室内に直接燃料を噴射する筒内噴射弁を備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、火花点火燃焼運転から圧縮自己着火燃焼運転に燃焼切り替えを行う際に、火花点火燃焼は圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行った後に、圧縮自己着火燃焼を開始することを要旨とする。

【００２０】請求項２記載の発明は、上記課題を解決するために、請求項１記載の圧縮自己着火式ガソリン機関において、圧縮自己着火燃焼運転から火花点火燃焼運転に燃焼切り替えを行う際に、火花点火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行うことを要旨とする。

【００２１】請求項３記載の発明は、上記課題を解決するために、燃焼室内に直接燃料を噴射する筒内噴射弁を備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、火花点火燃焼運転から圧縮自己着火燃焼運転に燃焼切り替えを行う際に、圧縮自己着火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行うことを要旨とする。

【００２２】請求項４記載の発明は、上記課題を解決するために、請求項３記載の圧縮自己着火式ガソリン機関において、圧縮自己着火燃焼運転から火花点火燃焼運転に燃焼切り替えを行う際に、圧縮自己着火燃焼時に圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行った後に火花点火燃焼を行うことを要旨とする。

【００２３】請求項５記載の発明は、上記課題を解決するために、燃焼室内に直接燃料を噴射する筒内噴射弁と吸排気弁の開閉時期を変更する開閉時期可変手段とを備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、火花点火燃焼から圧縮自己着火燃焼に切り替える際に、前記開閉時期可変手段により圧縮上死点付近で吸排気弁が共に閉じた密閉期間を設け、圧縮自己着火燃焼はまず前記密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行うことを要旨とする。

【００２４】請求項６記載の発明は、上記課題を解決するために、請求項５に記載の圧縮自己着火式ガソリン機関において、圧縮自己着火燃焼から火花点火燃焼に切り替える際に、前記密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行った後に火花点火燃焼を行うことを要旨とする。

【００２５】請求項７記載の発明は、上記課題を解決するために、燃焼室内に直接燃料を噴射する筒内噴射弁を備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、火花点火燃焼運転から圧縮自己着火燃焼運転に燃焼切り替えを行う際に、火花点火燃焼は圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行った後に、圧縮自己着火燃焼を開始し、圧縮自己着火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行うことを要旨とする。

【００２６】請求項８記載の発明は、上記課題を解決するために、請求項７に記載の圧縮自己着火式ガソリン機関において、圧縮自己着火燃焼運転から圧縮自己着火燃焼運転に燃焼切り替えを行う際に、圧縮自己着火燃焼は圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行った後に、火花点火燃焼を開始し、火花点火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行うことを要旨とする。

【００２７】請求項９記載の発明は、上記課題を解決するために、燃焼室内に直接燃料を噴射する筒内噴射弁と吸排気弁の開閉時期を変更する開閉時期可変手段とを備え、火花点火燃焼と圧縮自己着火燃焼とを運転条件により動的に切り替える圧縮自己着火式ガソリン機関において、火花点火燃焼から圧縮自己着火燃焼に切り替える際に、前記開閉時期可変手段により圧縮上死点付近で吸排気弁が共に閉じた密閉期間を設け、圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行った後に、圧縮自己着火燃焼を開始し、圧縮自己着火燃焼は、まず前記密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行うことを要旨とする。

【００２８】請求項１０記載の発明は、上記課題を解決するために、請求項９記載の圧縮自己着火式ガソリン機関において、圧縮自己着火燃焼から火花点火燃焼に切り替える際に、圧縮自己着火燃焼は、前記密閉期間中に燃料噴射を行う圧縮自己着火燃焼を行った後に、火花点火燃焼を行い、火花点火燃焼はまず圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行うことを要旨とする。

【００２９】請求項１１記載の発明は、上記課題を解決するために、請求項１，３，５，７，９のいずれか１項に記載の圧縮自己着火式ガソリン機関において、前記火花点火燃焼から圧縮自己着火燃焼への切り替え直前の点火タイミングは、同一機関回転数及び同一負荷条件にお

ける定常状態の点火タイミングに対して遅角させることを要旨とする。

【００３０】請求項１２記載の発明は、上記課題を解決するために、請求項１１に記載の圧縮自己着火式ガソリン機関において、前記火花点火燃焼から圧縮自己着火燃焼へ切り替え後、圧縮上死点前３０°付近で点火プラグに放電して圧縮自己着火を促進し、圧縮自己着火燃焼の開始後に火花点火を停止することを要旨とする。

【００３１】請求項１３記載の発明は、上記課題を解決するために、請求項５または請求項９に記載の圧縮自己着火式ガソリン機関において、前記火花点火燃焼から圧縮自己着火燃焼への切り替え時に、燃料の一部にのみを前記密閉期間中に噴射するとともに、燃料の残部を機関の負荷に応じて、圧縮行程中または吸気行程中に噴射することを要旨とする。

【００３２】請求項１４記載の発明は、上記課題を解決するために、請求項１３に記載の圧縮自己着火式ガソリン機関において、前記火花点火燃焼から圧縮自己着火燃焼への切り替え時に、前記密閉期間中に噴射する燃料量を、通常の圧縮自己着火燃焼時に対して増量したことを要旨とする。

【００３３】請求項１５記載の発明は、上記課題を解決するために、請求項５，９，１１，１２，１３，１４のいずれか１項に記載の圧縮自己着火式ガソリン機関において、前記火花点火燃焼から圧縮自己着火燃焼への切り替え時に、前記密閉期間の長さを燃焼切り替え時の負荷に応じて低負荷側は略一定とし、所定の負荷を超えたところから負荷の増加に応じて前記密閉期間の長さを減少させることを要旨とする。

【００３４】請求項１６記載の発明は、上記課題を解決するために、請求項1ないし請求項１５のいずれか１項記載の圧縮自己着火式ガソリン機関において、前記火花点火燃焼から圧縮自己着火燃焼への切り替え時に、燃焼切り替えを行う気筒を少なくとも２つ以上のグループに分けて、グループ間で時間をずらして順次燃焼の切り替えを行うことを要旨とする。

【００３５】

【発明の効果】請求項１記載の本発明によれば、火花点火燃焼運転から圧縮自己着火燃焼運転への動的な切り替えを行う際に、火花点火燃焼は圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行う。これによって、火花点火燃焼から圧縮自己着火燃焼への切り替え時の筒内圧力を高くすることができるため、圧縮自己着火燃焼時の燃焼を安定させることができる。その結果、運転時に切り替え時の燃焼不安定を抑制することができ、運転性の悪化を防止することができるという効果がある。

【００３６】請求項２記載の本発明によれば、圧縮自己着火燃焼運転から火花点火燃焼運転への動的な切り替えを行う際に、火花点火燃焼は圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行う。これによって、均質の火花点火運転を行った場合に対して、火花点火運転時の燃料量の増加を抑制することができ、火花点火燃焼時のノッキングの発生を防止することができる。その結果、運転時に切り替え時のノッキングを抑制することができ、運転性の悪化を防止することができるという効果がある。

【００３７】請求項３記載の本発明によれば、火花点火燃焼運転から圧縮自己着火燃焼運転への動的な切り替えを行う際に、圧縮自己着火燃焼は圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行う。これによって、圧縮自己着火燃焼時の着火性を改善することができるため、圧縮自己着火燃焼時の燃焼を安定させることができる。その結果、運転時に切り替え時の燃焼不安定を抑制することができ、運転性の悪化を防止することができるという効果がある。

【００３８】請求項４記載の本発明によれば、圧縮自己着火燃焼運転から火花点火燃焼運転への動的な切り替えを行う際に、圧縮自己着火燃焼は圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行う。これによって、圧縮自己着火燃焼時の着火性を改善することができるため、燃焼切り替え後の火花点火燃焼の燃料噴射量を少なくでき、ノッキングを防止することができる。その結果、運転時に切り替え時のノッキングを抑制することができ、運転性の悪化を防止することができるという効果がある。

【００３９】請求項５記載の本発明によれば、火花点火燃焼運転から圧縮自己着火燃焼運転への動的な切り替えを行う際に、排気上死点付近で吸気及び排気弁が共に閉じて燃焼室が密閉された密閉期間を有するように、吸排気弁の開閉時期を変更し、前記密閉期間中に燃料を噴射することにより火花点火燃焼運転から圧縮自己着火燃焼に燃焼状態を切り替えるようにしたので、開閉時期可変手段による吸排気弁の開閉切り替えの応答性が遅くても、１燃焼サイクルで火花点火燃焼から圧縮自己着火燃焼へ確実に切り替えることができるという効果がある。

【００４０】請求項６記載の本発明によれば、圧縮自己着火燃焼運転から火花点火燃焼運転への動的な切り替えを行う際に、排気上死点付近で吸気及び排気弁が共に閉となる密閉期間を有するように、吸排気弁の開閉時期を変更し、前記密閉期間中に燃料を噴射することにより圧縮自己着火燃焼運転から火花点火燃焼状態を切り替えるようにした。これによって、圧縮自己着火燃焼時の負荷を低下することができるため、燃焼切り替え後の火花点火燃焼の燃料噴射量を少なくでき、ノッキングを防止することができる。その結果、運転時に切り替え時のノッキングを抑制することができ、運転性の悪化を防止することができるという効果がある。

【００４１】請求項７記載の本発明によれば、火花点火燃焼運転から圧縮自己着火燃焼運転への動的な切り替えを行う際に、火花点火燃焼時は圧縮行程中に燃料噴射を

行う成層状態の火花点火燃焼を行い、圧縮自己着火燃焼は圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行う。これによって、火花点火燃焼から圧縮自己着火燃焼への切り替え時の筒内圧力を高くすることができるため、圧縮自己着火燃焼時の燃焼を安定させることができる。更に、圧縮自己着火燃焼時の着火性を改善することができるため、圧縮自己着火燃焼時の燃焼を安定させることができる。その結果、運転時に切り替え時の燃焼不安定を抑制することができ、運転性の悪化を防止することができるという効果がある。

【００４２】請求項８記載の本発明によれば、圧縮自己着火燃焼運転から火花点火燃焼運転への動的な切り替えを行う際に、圧縮自己着火燃焼は圧縮行程中に燃料噴射を行う成層状態の圧縮自己着火燃焼を行い、火花点火燃焼時は圧縮行程中に燃料噴射を行う成層状態の火花点火燃焼を行う。これによって、圧縮自己着火燃焼時の負荷を低下することができるため、燃焼切り替え後の火花点火燃焼の燃料噴射量を少なくでき、ノッキングを防止することができる。その結果、運転時に切り替え時のノッキングを抑制することができ、運転性の悪化を防止することができる。更に、均質の火花点火運転を行った場合に対して、火花点火運転時の燃料量の増加を抑制することができ、火花点火燃焼時のノッキングの発生を防止することができる。その結果、運転時に切り替え時のノッキングを抑制することができ、運転性の悪化を防止することができるという効果がある。

【００４３】請求項９記載の本発明によれば、火花点火燃焼運転から圧縮自己着火燃焼運転に切り替える際に、排気上死点付近で吸気弁及び排気弁が共に閉となる密閉期間を有するように開閉時期を変更するとともに、火花点火による成層燃焼を行った後、前記密閉期間中に燃料を噴射することにより火花点火燃焼から圧縮自己着火燃焼運転に燃焼を切り替えるようにしたので、低トルク領域においてもトルク変動の少ない滑らかな燃焼切り替えができるという効果がある。

【００４４】請求項１０記載の本発明によれば、圧縮自己着火燃焼運転から火花点火燃焼運転に切り替える際に、排気上死点付近で吸気弁及び排気弁が共に閉となる密閉期間を有するように開閉時期を変更するとともに、前記密閉期間中に燃料を噴射する圧縮自己着火燃焼を行った後、成層状態の火花点火燃焼を行う。これにより、圧縮自己着火燃焼時の負荷を低下することができるため、燃焼切り替え後の火花点火燃焼の燃料噴射量を少なくでき、ノッキングを防止することができる。更に、均質の火花点火運転を行った場合に対して、火花点火運転時の燃料量の増加を抑制することができ、火花点火燃焼時のノッキングの発生を防止することができる。その結果、運転時に切り替え時のノッキングを抑制することができ、運転性の悪化を防止することができるという効果がある。

【００４５】請求項１１記載の本発明によれば、火花点火燃焼から圧縮自己着火燃焼への切り替え直前の点火タイミングは同一機関回転数及び同一負荷条件における定常状態の点火タイミングに対して遅角させるようにしたので、燃焼熱の発生時期を遅らせ、温度の高い既燃ガスを内部ＥＧＲに用いて、圧縮自己着火を容易に起こさせることができる効果がある。

【００４６】請求項１２記載の本発明によれば、燃焼切り替え後の圧縮自己着火燃焼開始時に、点火プラグより圧縮上死点前３０°付近で放電により発生したラジカルにより燃料が改質され圧縮自己着火を容易に起こさせることができる効果がある。

【００４７】請求項１３記載の本発明によれば、火花点火燃焼から圧縮自己着火燃焼への切り替え時に、燃料の一部のみを密閉期間中に噴射するとともに、残りの燃料を期間の負荷に応じて、圧縮行程中または吸気行程中に噴射するようにしたので、圧縮過程で行われる燃料改質を過不足無く行うことができ、圧縮自己着火を安定的に起こさせるという効果がある。

【００４８】請求項１４記載の本発明によれば、火花点火燃焼から圧縮自己着火燃焼への切り替え時に、密閉期間中に噴射する燃料量を、通常の圧縮自己着火燃焼時に対し増量するようにしたので、燃料改質を強化して圧縮自己着火開始点の燃焼安定性をさらに高めることができるという効果がある。

【００４９】請求項１５記載の本発明によれば、火花点火燃焼から圧縮自己着火燃焼への切り替え時に、密閉期間の長さを燃焼切り替え時の負荷に応じて低負荷側は略一定とし、所定の負荷を超えたところから負荷の増加に応じて密閉期間の長さを減少させるようにしたので、低負荷時の燃料改質時間を確保するとともに、高負荷時に燃料改質が進みすぎてノッキングが発生することを防止することができるという効果がある。

【００５０】請求項１６記載の本発明によれば、火花点火燃焼から圧縮自己着火燃焼への切り替え時に、燃焼切り替えを行う気筒を少なくとも２つ以上のグループに分けて、グループ間で時間をずらして順次燃焼の切り替えを行うようにしたので、火花点火燃焼から圧縮自己着火燃焼への切り替え時の機関トルク変動を十分抑制することができるという効果がある。

【００５１】

【発明の実施の形態】以下、図面に基づいて本発明の実施の形態について説明する。図１は、本発明に係る圧縮自己着火ガソリン内燃機関の第１の実施の形態の構成を示すシステム構成図である。

【００５２】本実施形態においては、運転条件に応じて圧縮自己着火燃焼と火花点火燃焼とを機関運転中に動的に切換可能となっている。図中のエンジン本体１０は、吸気ポート１１、排気ポート１２、ピストン１３、吸気バルブ１４、排気バルブ１５、クランク角センサ１６、

燃料噴射装置１７、点火プラグ１８、スロットルバルブ１９を備えている。

【００５３】このエンジン本体１０を制御する電子制御装置（以下、ＥＣＵと略す）１は、運転条件に応じて圧縮自己着火燃焼と火花点火燃焼のいずれかの燃焼方式で運転を行うかを判定する燃焼パターン判定部２と、火花点火燃焼運転時の燃焼パラメータを制御する火花点火燃焼制御部３と、圧縮自己着火燃焼運転時の燃焼制御パラメータを制御する自己着火燃焼制御部４と、圧縮自己着火燃焼と火花点火燃焼との切り替えが必要か不要かを判定する燃焼切り替え判定部５と、燃焼切替が必要な場合に燃焼噴射時期、燃料噴射量、点火時期を制御して円滑な燃焼切替を実現する燃焼切り替え制御部６とを備えている。

【００５４】尚、ＥＣＵ１の構成要素である、燃焼パターン判定部２、火花点火燃焼制御部３、自己着火燃焼制御部４、燃焼切り替え判定部５、及び燃焼切り替え制御部６は、マイクロコンピュータのプログラムとして実現されている。

【００５５】またＥＣＵ１は、クランク角センサ１６が検出したエンジン回転数信号、及びアクセル開度センサ（図示せず）が検出したアクセル開度信号（負荷）に基づいて、運転条件を判定し、燃焼パターンを判断する。また運転条件に応じて燃料噴射量、燃料噴射時期、点火時期を算出する。そして、この算出結果に基づき、燃料噴射装置１７、点火プラグ１８に信号を送る。

【００５６】また吸気ポート１１の上流には、空気量調整用のスロットルバルブ１９と図示しないが空気量測定用のエアフロメータとエアクリーナと配管からなる吸気系が設けられている。

【００５７】このような構成のもと、本実施形態では図２に示すような、低回転、低中負荷の特定の運転条件において圧縮自己着火燃焼を行い、極低負荷、高負荷または高回転域においては火花点火燃焼を行う。

【００５８】次に、第１の実施形態の動作について説明する。図３は、空燃比に対する自己着火燃焼が成立する範囲を示すものである。燃料噴射は上死点から十分に進角した時期に行われており、混合気は予混合状態となっている。空燃比をリーンにしていくと燃焼安定度が悪化し、機関のトルク変動が大きくなる。このため、内燃機関としての設計値、またはこの内燃機関を搭載した車両の性格等として許容できる安定度が安定度限界値Ｓｔｈとなる空燃比ＡＦＬがリーン限界となる。

【００５９】一方、空燃比をリッチにしていくと、ノッキング強度が増大する。これによりノッキング限界Ｎｔｈにおける空燃比ＡＦＲがリッチ限界となる。従って、安定度限界空燃比ＡＦＬとノッキング限界空燃比ＡＦＲとで囲まれる空燃比領域が自己着火燃焼成立範囲となる。

【００６０】このように、自己着火は限られた空燃比範囲でしか成立しない。尚、ここではガスと燃料の割合を表す指標として空燃比Ａ／Ｆを例に説明した。残留ガスあるいはＥＧＲガスが含まれる場合についても同様の傾向を示し、この際には横軸は新気と既燃ガスを合わせたトータルのガス量と燃料割合Ｇ／Ｆとなる。

【００６１】図３では燃焼パラメータとして空燃比に対する自己着火燃焼成立範囲を示したが、空燃比以外にも温度、吸気圧あるいは過給圧に対しても同様な傾向を示す。すなわち温度が低下すると燃焼安定度が悪化し、温度が上昇するとノッキング強度が増大する。また吸気圧、過給圧についても圧力が低下すると燃焼安定度が悪化し、圧力が増加するとノッキング強度が増大する。従って、安定した自己着火燃焼を維持するためには、要求される温度、圧力を制御する必要がある。

【００６２】図４は、第１実施形態における火花点火燃焼運転から自己着火燃焼運転が切り替わる条件について示している。図４に示すように燃焼パターンの切り替えは２種類存在する。低負荷域で火花点火燃焼から圧縮自己着火燃焼あるいは圧縮自己着火燃焼から火花点火燃焼に切り替わる場合と、高負荷域で圧縮自己着火燃焼から火花点火燃焼あるいは火花点火燃焼から圧縮自己着火燃焼に切り替わる場合である。

【００６３】本発明は低負荷域で燃焼形態が切り替わる場合についてのものとなっている。図５には負荷に対するスロットル開度と筒内圧力を示している。火花点火燃焼は均質のストイキ燃焼となっている。低負荷域で燃焼形態が火花点火燃焼から圧縮自己着火燃焼に切り替える場合、スロットル開度が大きく異なる。このため筒内圧力が大きく異なることになる。このため燃焼形態が圧縮自己着火燃焼に切り替わった場合に、筒内圧力が不足し、前述したように燃焼が不安定になる可能性がある。

【００６４】図６には低負荷域において火花点火燃焼を成層燃焼とした場合の、負荷に対するスロットル開度と筒内圧力を示している。成層燃焼を行う場合には、空気量を大きくしたまま、空燃比をリーンにできるため、スロットル開度を大きくすることができる。よって、筒内圧力も均質ストイキ燃焼に比べて、高く保つことができる。このため、燃焼状態を切り替える場合に筒内圧力が短い時間で目標値にできるため、燃焼が不安定になるのを防止することができる。

【００６５】図７には圧縮自己着火燃焼時に成層燃焼を行った場合の負荷に対するスロットル開度と筒内圧力を示す。圧縮自己着火燃焼時に成層燃焼を行った場合には、圧縮自己着火燃焼が可能となる負荷を低負荷化できる。このため燃焼切り替えを行う負荷も低負荷化することになる。燃焼切り替えを行う負荷を低負荷した場合には、燃焼する燃料量が少なくなるため、火花点火燃焼、圧縮自己着火燃焼共に、ノッキングを起こし難くなる。すなわち、負荷が低いため燃焼する燃料量は少なく、燃焼時の発熱量が少なくなる。よって燃焼切り替え時に筒

内圧力、温度等の燃焼パラメータが目標値からずれた場合においてもノッキングを起こし難い。

【００６６】図８に燃焼状態を切り替える時の燃焼形態を示す。機関が定常運転している場合には、極低負荷時にストイキ均質の火花点火燃焼を行う。中負荷時に均質の圧縮自己着火燃焼を行う。負荷が変化する過渡時には、低負荷から順に、ストイキ均質の火花点火燃焼を行い、次に成層の火花点火燃焼を行い、次に成層の圧縮自己着火燃焼を行い、最後に均質の圧縮自己着火燃焼を行う。

【００６７】以上説明してきた切り替え制御の流れをフローチャートを参照して説明する。図９に燃焼パターンを制御するメインフローチャートを示す。ステップ１１（以下Ｓ１１）でエンジン回転数Ｎ、負荷Ｔを検出する。次いでＳ１２で図３のマップから運転条件に応じた燃焼パターンを判断する。火花点火燃焼と判断された場合にはＳ１３で火花点火燃焼制御を開始する。自己着火燃焼と判断された場合にはＳ１４で自己着火燃焼制御を開始する。燃焼切り替えと判断された場合にはＳ１５で燃焼切り替え制御を開始する。

【００６８】図１０に火花点火燃焼から圧縮自己着火燃焼に燃焼を切り替える場合の制御フローチャートを示す。まず、Ｓ２１でスロットル開度を変更する。次いでＳ２２でスロットル開度が図６に示す目標値に設定されているかどうか判断する。スロットル開度の設定が終了していない場合には、ストイキの均質燃焼を続けるためＳ２３で吸気行程噴射を続ける。Ｓ２２でスロットル開度の設定が終了したと判断された場合にはＳ２４で圧縮行程噴射を行い、成層状態の火花点火燃焼を行う。

【００６９】次いで、Ｓ２５で再度スロットル開度を変更する。Ｓ２６でスロットル開度が図６に示す目標値に設定されているかどうか判断する。スロットル開度の設定が終了していない場合には火花点火燃焼を続けるため、Ｓ２７で火花点火を行う。Ｓ２６でスロットル開度の設定が完了したと判断された場合にはＳ２８で火花点火をオフして圧縮自己着火燃焼を開始する。Ｓ２９で機関の負荷が図８のグラフに示す均質燃焼負荷領域がどうか判断する。均質燃焼領域でない場合には、Ｓ３０で圧縮行程噴射を行い、成層状態の圧縮自己着火燃焼を行う。Ｓ２９で均質燃焼負荷領域と判断された場合にはＳ３１で吸気行程噴射を行い、均質状態の圧縮自己着火燃焼を開始する。

【００７０】図１１に圧縮自己着火燃焼から火花点火燃焼に燃焼を切り替える場合の制御フローチャートを示す。図９のフローチャートで燃焼切り替えと判断された場合に、まずＳ４１で圧縮行程噴射を行い、成層状態の圧縮自己着火燃焼を開始する。Ｓ４２でスロットル開度を変更して、Ｓ４３でスロットル開度が図６に示す目標値に設定されているかどうか判断する。スロットル開度の設定が終了していない場合にはＳ４４で火花点火をオフとして圧縮自己着火燃焼を続ける。Ｓ４３でスロットル開度の設定が完了したと判断された場合にはＳ４５で火花点火をオンとして、火花点火燃焼を開始する。

【００７１】次いで、Ｓ４６で再度スロットル開度を変更する。Ｓ４７で図６に示す目標値に設定されているかどうか判断する。目標値に設定されていない場合にはＳ４８で圧縮行程噴射を行い、成層状態火花点火燃焼を続ける。Ｓ４７でスロットル開度の設定が完了していると判断された場合には、Ｓ４９で吸気行程噴射を行い、均質状態の火花点火燃焼を開始する。

【００７２】次に、第２の実施の形態について説明する。図１２は本発明に係る圧縮自己着火式ガソリン機関の第２の実施の形態の構成を示すシステム構成図である。第２の実施の形態は第１の実施の形態に対して、吸排気弁の開閉時期を変更する可変バルブタイミング機構２０を追加した構成となっている。可変バルブタイミング機構としては、例えば、特開平１０－２６６８７８号公報記載の技術が利用できる。

【００７３】本実施形態の吸排気弁の開閉タイミングを図１３に示す。火花点火運転時には、通常の４サイクルガソリン機関と同様に排気バルブ（ＥＸＨ）の閉弁時期（ＥＶＣ）と吸気バルブ（ＩＮＴ）の開弁時期（ＩＶＯ）とがピストン上死点（ＴＤＣ）付近となって所要のバルブオーバラップ（Ｏ／Ｌ）に設定される。

【００７４】燃焼状態を切り替える際の特定の運転領域における圧縮自己着火運転時は、火花点火運転に対して排気バルブ閉時期（ＥＶＯ）が進角して吸気行程途中に閉弁すると共に、吸気バルブ開時期（ＩＶＯ）が遅角して吸気行程途中に開弁するように制御されて、ピストン上死点付近におけるバルブオーバラップは全く存在せず、燃焼室を密閉した密閉期間であるマイナスオーバラップ（－Ｏ／Ｌ）状態に設定される。

【００７５】このように圧縮自己着火運転時にマイナスオーバラップを成すバルブタイミングとすることにより、排気バルブが排気行程中途にて閉弁されてその時点での燃焼室容積に相当する高温の既燃ガスを燃焼室内に滞留させて、次サイクルへの内部ＥＧＲガスとする。次サイクルでは吸気行程途中で吸気バルブが開弁して新気が吸入される。ここで新気は内部ＥＧＲガスからの熱量を受けて、筒内温度が昇温することになる。

【００７６】ここで－Ｏ／Ｌ中に燃料噴射を行うと、燃料は筒内に閉じこめられた高温のガスからの熱量を受けて改質される。その結果、燃料の着火性が改善されより低負荷条件での圧縮自己着火燃焼が可能になる。

【００７７】図１４には低負荷時に－Ｏ／Ｌ噴射による圧縮自己着火燃焼を行った場合の負荷に対するスロットル開度と筒内圧力を示している。図７に比べてより低負荷条件における圧縮自己着火燃焼が可能となっている。このため燃焼切り替えを行う負荷も低負荷化することになる。燃焼切り替えを行う負荷を低負荷した場合には、

燃焼する燃料量が少なくなるため、火花点火燃焼、圧縮自己着火燃焼共に、ノッキングを起こし難くなる。すなわち、負荷が低いため燃焼する燃料量は少なく、燃焼時の発熱量が少なくなる。よって燃焼切り替え時に筒内圧力、温度等の燃焼パラメータが目標値からずれた場合においてもノッキングを起こし難い。

【００７８】図１５に燃焼状態を切り替える時の燃焼形態を示す。機関が定常運転している場合には、極低負荷時にストイキ均質の火花点火燃焼を行う。中負荷時に均質の圧縮自己着火燃焼を行う。負荷変化する過渡時には、低負荷から順に、ストイキ均質の火花点火燃焼を行い、次に成層の火花点火燃焼を行い、次に－Ｏ／Ｌ中噴射の圧縮自己着火燃焼を行い、最後に均質の圧縮自己着火燃焼を行う。

【００７９】燃焼パターンを制御するフローチャートは、第１の実施形態（図９）と同じである。

【００８０】図１６に火花点火燃焼から圧縮自己着火燃焼に燃焼を切り替える場合の制御フローチャートを示す。第１の実施形態（図１０）と異なる所のみ説明する。Ｓ５５でスロットル開度とバルブタイミングを変更する。Ｓ５６で－Ｏ／Ｌ噴射を開始する。Ｓ５７でスロットル開度、バルブタイミングが目標値（図１３；１４）に設定されたかどうか判断する。設定が完了していない場合にはＳ５８で火花点火をオンとして火花点火燃焼を続ける。Ｓ５７で設定が完了したと判断された場合にはＳ５９で火花点火をオフして圧縮自己着火燃焼を開始する。

【００８１】次いでＳ６０で図１５をもとに均質燃焼負荷領域かどうか判断する。均質燃焼負荷領域でない場合にはＳ６１で－Ｏ／Ｌ噴射を続ける。均質燃焼領域と判断された場合にはＳ６２で吸気行程噴射を開始して均質状態の圧縮自己着火燃焼を行う。

【００８２】図１７に圧縮自己着火燃焼から火花点火燃焼に燃焼を切り替える場合の制御フローチャートを示す。第１の実施形態（図１１）と異なる所のみ説明する。Ｓ７３でスロットル開度とバルブタイミングを変更する。Ｓ７２で－Ｏ／Ｌ噴射を開始する。Ｓ７３でスロットル開度とバルブタイミングの設定が完了したかどうか判断する。

【００８３】設定が完了していないと判断された場合には、Ｓ７４で火花点火をオフのままとして圧縮自己着火燃焼を続ける。Ｓ７３で設定が完了したと判断された場合には、Ｓ７５で噴射タイミングを圧縮行程噴射として、Ｓ７６で火花点火を開始して、成層状態の火花点火燃焼を開始する。

【００８４】次に、図１８ないし図２２を参照して、本発明の第３の実施形態を詳細に説明する。図１８は、本発明に係る圧縮自己着火式ガソリン機関の第３の実施形態の構成を示すシステム構成図である。本実施形態においても運転条件に応じて圧縮自己着火燃焼と火花点火燃焼とを機関運転中に動的に切換可能となっている。

【００８５】図中のエンジン本体１０は、吸気ポート１１、排気ポート１２、ピストン１３、吸気バルブ１４、排気バルブ１５、クランク角センサ１６、筒内に直接燃料を噴射する燃料噴射装置１７、点火プラグ１８を備えている。

【００８６】このエンジン本体１０を制御する電子制御装置（以下、ＥＣＵと略す）１は、運転条件に応じて圧縮自己着火燃焼と火花点火燃焼のいずれかの燃焼方式で運転を行うかを判定する燃焼パターン判定部２と、火花点火燃焼運転時の燃焼パラメータを制御する火花点火燃焼制御部３と、圧縮自己着火燃焼運転時の燃焼制御パラメータを制御する自己着火燃焼制御部４と、圧縮自己着火燃焼と火花点火燃焼との切り替えが必要か不要かを判定する燃焼切り替え判定部５と、燃焼切替が必要な場合に燃焼噴射時期、燃料噴射量、点火時期を制御して円滑な燃焼切替を実現する燃焼切り替え制御部６とを備えている。

【００８７】尚、ＥＣＵ１の構成要素である、燃焼パターン判定部２、火花点火燃焼制御部３、自己着火燃焼制御部４、燃焼切り替え判定部５、及び燃焼切り替え制御部６は、マイクロコンピュータのプログラムとして実現されている。

【００８８】またＥＣＵ１は、クランク角センサ１６が検出したエンジン回転数信号、及びアクセル開度センサ（図示せず）が検出したアクセル開度信号（負荷）に基づいて、運転条件を判定し、燃焼パターンを判断する。また運転条件に応じて燃料噴射量、燃料噴射時期、点火時期を算出する。そして、この算出結果に基づき、燃料噴射装置１７、点火プラグ１８に信号を送る。

【００８９】また吸気ポート１１の上流には、図示しないが空気量調整用のスロットルバルブと空気量測定用のエアフロメータとエアクリーナと配管からなる吸気系が設けられている。

【００９０】吸気弁１４および排気弁１５は、それぞれＥＣＵ１により、開閉時期可変手段である可変バルブタイミング機構２０を介して開閉時期を制御可能な構成とすることで、機関の低中負荷域では実質的な圧縮比の変更、ＥＧＲ量などを制御し、圧縮上死点付近で自己着火が可能な高温、高圧状態を実現できる構成としている。

【００９１】次に、本実施形態における吸・排気弁の開閉タイミングの制御を図１９に示す。通常の火花点火燃焼時では排気上死点（ＴＤＣ）付近においてクランク角度にして数度から十数度程度の期間、吸・排気弁がともに開いている開弁重合期間（オーバーラップ期間）を有している。一方、圧縮自己着火燃焼時に排気作動角を縮小するとともに排気弁閉時期（以後ＥＶＣ）を排気ＴＤＣ前とし、かつ吸気作動角を縮小するとともに吸気弁開時期（以後ＩＶＯ）を排気ＴＤＣ後に制御することで、吸・排気弁がともに閉となる密閉期間を設けている。

【００９２】このような吸・排気弁の作動状態を可変とする機構としては、例えば特開昭５５－１３７３０５号公報、特開平９－２０３３０７号公報に示されるような可変動弁システムがある。

【００９３】圧縮自己着火燃焼時には、前記密閉期間を設けていることで、高温な排気ガスを閉じ込めることができるため、吸気が加熱され、過度な圧縮比増加を行なうことなくガソリン機関での圧縮自己着火燃焼を発生せしめることを可能としている。また、本発明では上記圧縮自己着火燃焼時のバルブタイミングを、火花点火燃焼から圧縮自己着火燃焼への切替え直前の火花点火燃焼にも用いる。

【００９４】次に、前記吸・排気弁がともに閉となる密閉期間を設けた場合の、スロットル開度一定条件における圧縮自己着火燃焼と火花点火燃焼の空燃比（Ａ／Ｆ）に対する燃焼安定性について図２０により説明する。

【００９５】圧縮自己着火燃焼において、燃料の少なくとも一部を前記密閉期間に噴射することにより、燃焼安定領域はＡ／Ｆのリーン側（すなわち低負荷側）に拡大することができる。これは密閉期間中に噴射された燃料が自己ＥＧＲガスとともに圧縮されるため、高温かつ高圧場に暴露され、自己ＥＧＲ中に存在する酸素と反応し、燃料が圧縮自己着火し易い状態に改質されるためである。

【００９６】更に圧縮自己着火燃焼時に燃料の少なくとも一部を圧縮行程に噴射することで、混合気を成層化する行うことで燃焼室内に部分的にＡ／Ｆがリッチ場ができるため、燃焼室全体としてのＡ／Ｆは、よりリーンな状態でも圧縮自己着火が可能となる。

【００９７】前記圧縮自己着火燃焼と同一密閉期間、同一スロットル開度における成層混合気での火花点火燃焼安定領域を図２０の破線で示す。圧縮自己着火燃焼が発生しない成層混合気場であっても、火花点火により火炎核を形成することで火炎伝播燃焼が可能となるＡ／Ｆの領域が存在する。

【００９８】よって前記Ａ／Ｆ領域では図中の矢印に示すように、同一のスロットル開度および同一吸・排気弁開閉時期でありながら燃料の噴射タイミングを変更することで、火花点火燃焼から圧縮自己着火燃焼へ移行が可能となる。

【００９９】次に本発明における基本となる燃焼切替え手順を図２１の実線により説明する。火花点火燃焼から圧縮自己着火燃焼への切替えは２段階に分けて実施する。

【０１００】第１段階では吸気行程中に燃料を噴射し理論混合比での均質予混合気における火花点火燃焼から、スロットル開度を大とするとともに燃料噴射タイミングを圧縮行程とした成層リーン混合気での火花点火燃焼へ移行する。

【０１０１】成層リーン燃焼に移行した後、吸・排気弁の開閉時期を圧縮自己着火燃焼で要求される前記密閉期間となるように変更する。この時、スロットルは自己ＥＧＲ量の増加により減少する新気量を補うため、前記密閉期間が伸びるのに対応し全開近くまで開弁する。この状態で図２０における●印の状態となる。

【０１０２】第２段階では火花点火燃焼から圧縮自己着火燃焼への移行であり、燃焼の移行は火花点火燃焼における圧縮行程中の噴射タイミングを前記密閉期間中の噴射に変更することで実施する。これにより燃焼状態は図２０の●印から○印へ移行する。同時に燃料噴射量も減少させせることで燃焼切替え時の負荷変動を吸収する。これは圧縮自己着火燃焼では火花点火燃焼に比べ燃焼期間が短いため熱効率の向上効果があるためである。またこの時、点火プラグにおける放電は圧縮自己着火燃焼への移行とともに中止しても構わない。

【０１０３】次に燃焼切替え時の負荷が前記基本状態に対し異なる場合の手順について、前記基本状態に対して低負荷の場合を図２１の破線で、高負荷の場合を図２１の一点鎖線で説明する。

【０１０４】切替え負荷が低い場合、火花点火燃焼における燃焼安定性を確保するためには、スロットル開度を圧縮自己着火燃焼での要求値まで開弁することが出来なくなる。低負荷時における火花点火燃焼から圧縮自己着火燃焼への移行では、前記基本状態と同様に燃料噴射タイミングを前記密閉期間に変更することで実施するが、同時にスロットルの開弁動作を伴うため吸気圧が上がるまでの圧縮自己着火燃焼が不安定となる。

【０１０５】この時の圧縮自己着火燃焼の安定性向上のため、燃料噴射の回数を第１の燃料噴射時期である前記密閉期間噴射に加え、第２の燃料噴射時期である圧縮行程噴射を追加して２回とする。そして、密閉期間噴射による燃料改質と圧縮行程噴射による成層化によって安定性を向上させる。

【０１０６】この噴射タイミングの切替えは図２０における●印から△印への移行と捉えることができ、前記圧縮行程噴射の追加により燃焼室内にリッチな混合気場が形成されるため圧縮自己着火燃焼が発生し易くなることを利用したものである。

【０１０７】燃焼切替え直後の燃料の全噴射量はスロットル開弁動作が終了した時点での全噴射量に対し増加させることで、燃焼安定性の向上、燃焼切替え時のトルク変動の低減効果を得ることができる。

【０１０８】また火花点火燃焼から圧縮自己着火燃焼への燃焼切替え直前の火花点火燃焼において、点火プラグにおける放電タイミングを遅角することで、自己ＥＧＲガスの温度を上昇させるとともに酸化反応途中のＨＣを自己ＥＧＲガス中に多く残留させることが可能となるため、燃焼切替え直後の圧縮自己着火燃焼を確実に発生させることができる。

【０１０９】更に圧縮自己着火燃焼時においてもＴＤＣ

前３０°付近で点火プラグから放電することで燃料の改質効果が増加するため、燃焼切替え時の圧縮自己着火燃焼の安定性向上を得ることができる。

【０１１０】高負荷時には前記密閉期間に燃料を全量噴射してしまうと、排気ＴＤＣでの発熱量が過大となり、燃費の悪化とともに圧縮自己着火燃焼の過早着火が発生してノッキングとなってしまう。よって、高負荷側では前記密閉期間の燃料噴射量を基本状態に対し減少させるとともに、燃料の噴射を前記密閉期間中と吸気行程中の２回とし燃料が過度に改質されることを防止する。

【０１１１】以上に述べた基本状態、低負荷時、高負荷時の３種類の負荷に対する燃焼切替え手順における燃料噴射時期および前記吸・排気弁の密閉時期の相違を図２２に示す。ただし、切替えの適切な負荷範囲は機関のベース圧縮比および吸入空気量等のの影響をうけるため、同一機関において必ずしも３種類の切替えを行なう必要はない。

【０１１２】また、本発明による火花点火燃焼から圧縮自己着火燃焼への燃焼切替えは、各気筒毎の燃料噴射弁の噴射タイミングの変更により実施しているため、各気筒毎に燃焼切替え時期を変更することが容易である。よって、噴射タイミングの切替を気筒毎又は気筒グループ毎に順次行なうことで、火花点火燃焼から圧縮自己着火燃焼への燃焼切替え時の機関トルク変動を低減することが可能である。

【図面の簡単な説明】

【図１】本発明に係る圧縮自己着火式ガソリン機関の第１の実施形態の構成図である。

【図２】エンジン回転数Ｎ、負荷Ｔに対する燃焼パターンを説明する図である。

【図３】圧縮自己着火燃焼時の空燃比に対するノッキング強度、安定度、燃焼時期を説明する図である。

【図４】第１の実施形態の燃焼切り替えを説明する図である。

【図５】負荷に対するスロットル開度、筒内圧力を説明する図である。

【図６】成層状態の火花点火燃焼を行う場合の負荷に対するスロットル開度、筒内圧力を説明する図である。

【図７】成層状態の圧縮自己着火燃焼を行う場合の負荷に対するスロットル開度、筒内圧力を説明する図である。

【図８】第１の実施形態における定常運転時と過渡運転時の燃焼状態を説明する図である。

【図９】燃焼パターン判断の制御フロー図である。

【図１０】第１の実施形態における火花点火燃焼から圧縮自己着火燃焼への燃焼切り替える場合の制御フローである。

【図１１】第１の実施形態における圧縮自己着火燃焼から火花点火燃焼への燃焼切り替える場合の制御フローである。

【図１２】第２の実施形態の構成を示すシステム構成図である。

【図１３】各燃焼状態における吸排気弁の開閉時期を示す図である。

【図１４】第２の実施形態における負荷に対するスロットル開度、筒内圧力を説明する図である。

【図１５】第２の実施形態における定常運転時と過渡運転時の燃焼状態を説明する図である。

【図１６】第２の実施形態における火花点火燃焼から圧縮自己着火燃焼への燃焼切り替える場合の制御フローである。

【図１７】第２の実施形態における圧縮自己着火燃焼から火花点火燃焼への燃焼切り替える場合の制御フローである。

【図１８】第３の実施形態の構成を示すシステム構成図である。

【図１９】第３の実施形態の各燃焼状態における吸・排気弁の開閉時期を示す図である。

【図２０】第３の実施形態における燃料噴射タイミングを変更した場合の圧縮自己着火燃焼安定領域を示す図である。

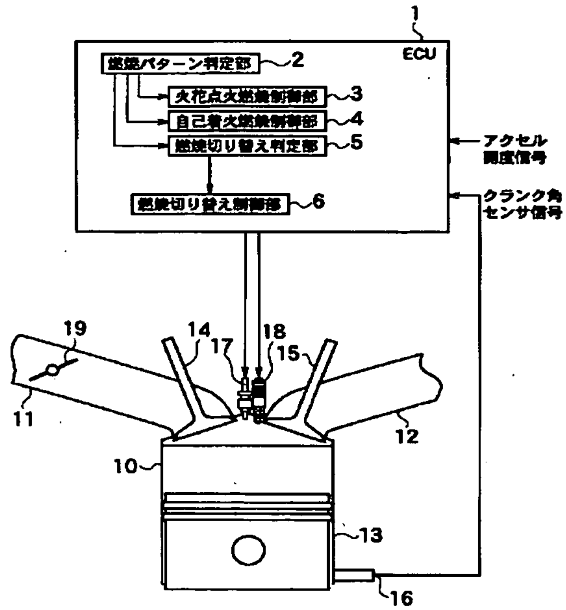
【図２１】第３の実施形態における燃焼切替えの手順を示すタイムチャートである。

【図２２】第３の実施形態における燃焼切替え時の機関負荷に対する相違を示す図である。

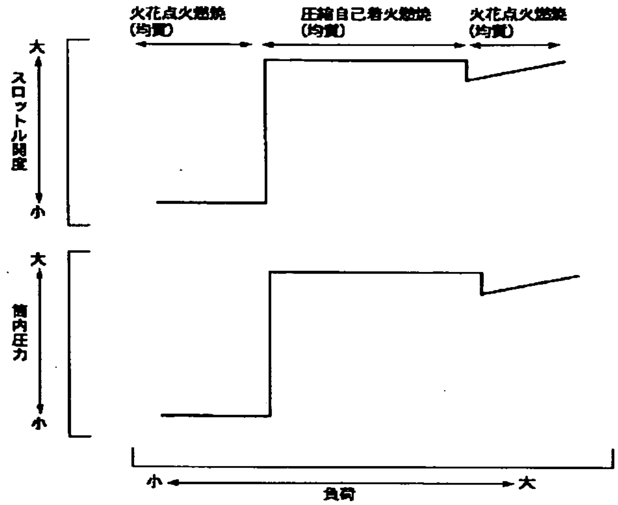
【符号の説明】

１　ＥＣＵ
２　燃焼パターン判定部
３　火花点火燃焼制御部
４　自己着火燃焼制御部
５　燃焼切り替え判定部
６　燃焼切り替え制御部
１０　エンジン本体
１１　吸気ポート
１２　排気ポート
１３　ピストン
１４　吸気バルブ
１５　排気バルブ
１６　クランク角センサ
１７　燃料噴射装置
１８　点火プラグ
１９　スロットルバルブ
２０　可変バルブタイミング機構

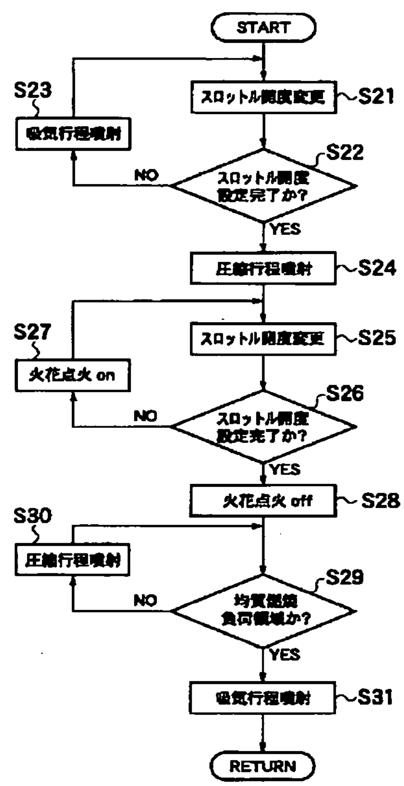
【図１】


1
ECU
燃焼パターン判定部
2
火花点火燃焼制御部
3
自己着火燃焼制御部
4
燃焼切り替え判定部
5
燃焼切り替え制御部
6
アクセル開度信号
クランク角センサ信号
19
14
17
18
15
11
12
10
13
16

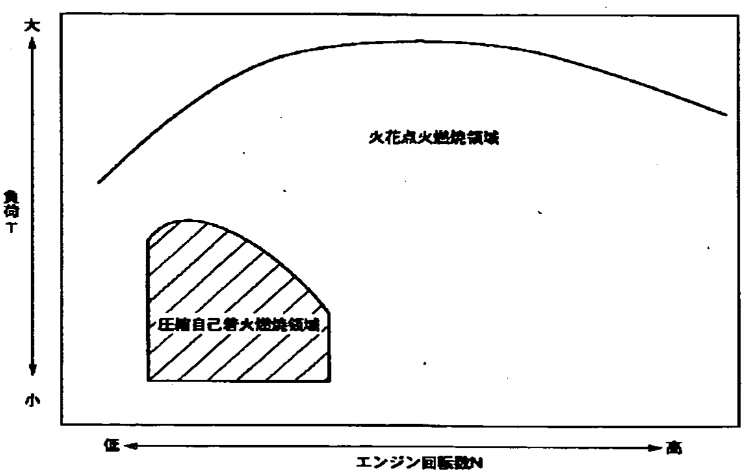
【図５】


火花点火燃焼(均質)
圧縮自己着火燃焼(均質)
火花点火燃焼(均質)
大
スロットル開度
小
大
筒内圧力
小
小
負荷
大

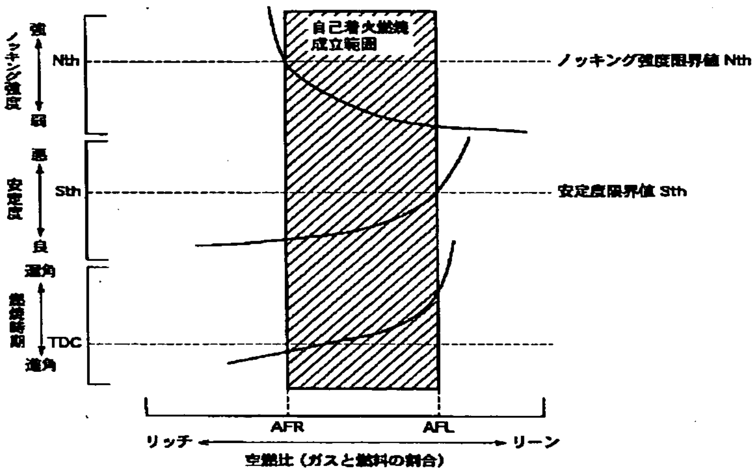
【図１０】


START
スロットル開度変更
S21
S23
吸気行程噴射
NO
スロットル開度設定完了か?
S22
YES
圧縮行程噴射
S24
スロットル開度変更
S25
S27
火花点火 on
NO
スロットル開度設定完了か?
S26
YES
火花点火 off
S28
S30
圧縮行程噴射
NO
均質燃焼負荷領域か?
S29
YES
吸気行程噴射
S31
RETURN

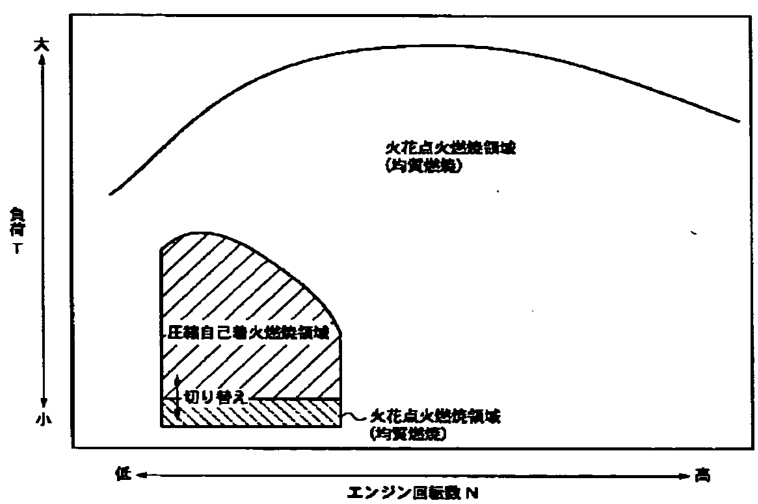
【図２】


大
負荷T
小
火花点火燃焼領域
圧縮自己着火燃焼領域
低
エンジン回転数N
高

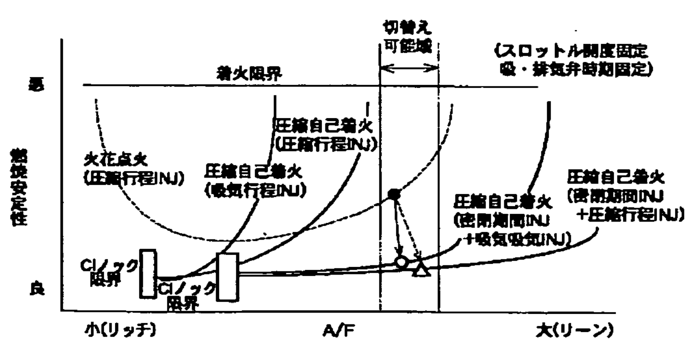
【図３】



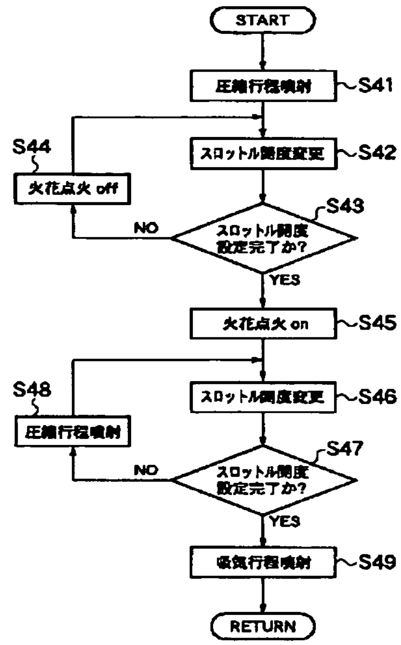
【図４】



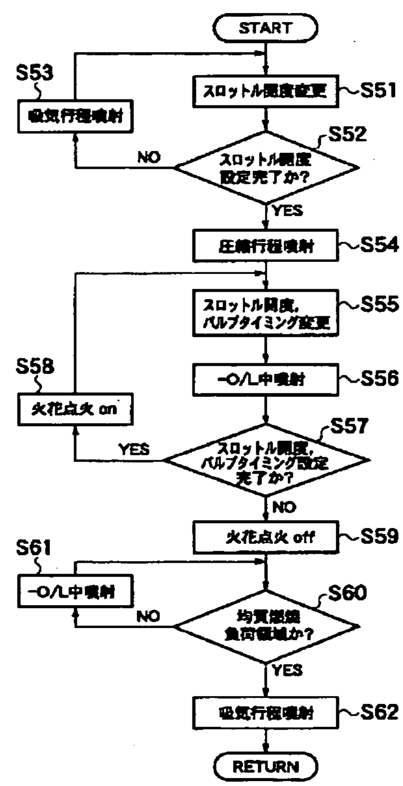
【図２０】



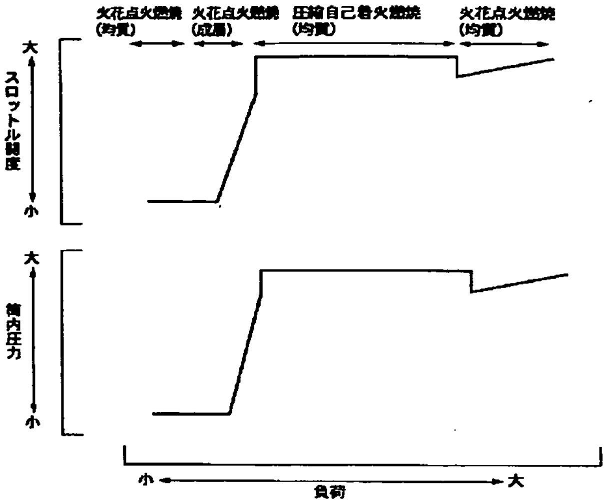
【図１１】



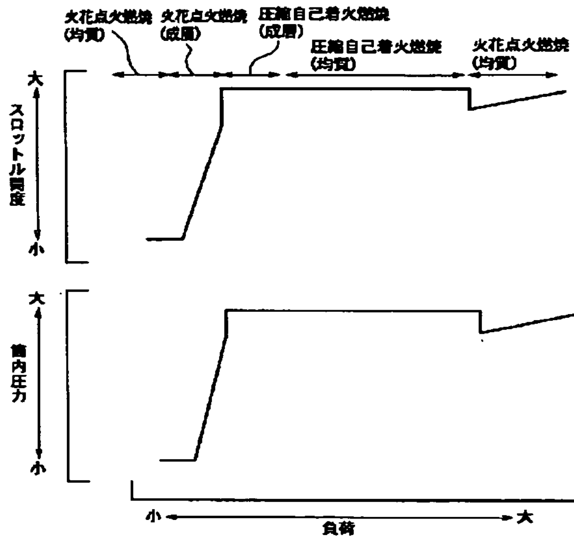
【図１６】



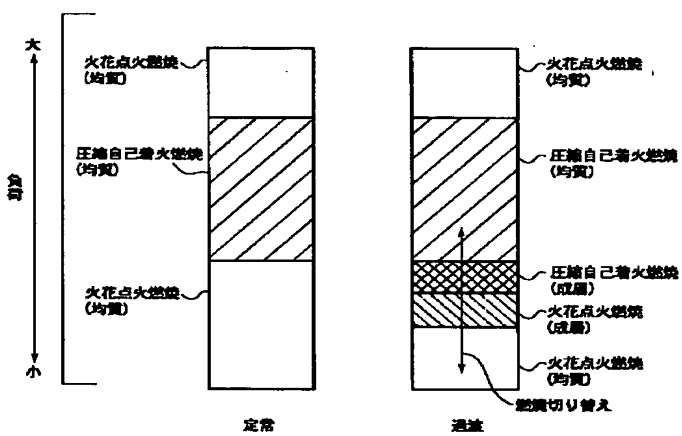
【図６】


火花点火燃焼
(均質)
火花点火燃焼
(成層)
圧縮自己着火燃焼
(均質)
火花点火燃焼
(均質)
大
スロットル開度
小
大
筒内圧力
小
小
負荷
大

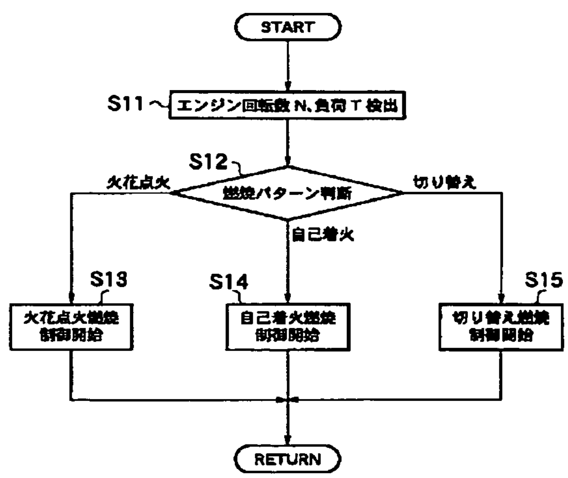
【図７】


火花点火燃焼
(均質)
火花点火燃焼
(成層)
圧縮自己着火燃焼
(成層)
圧縮自己着火燃焼
(均質)
火花点火燃焼
(均質)
大
スロットル開度
小
大
筒内圧力
小
小
負荷
大

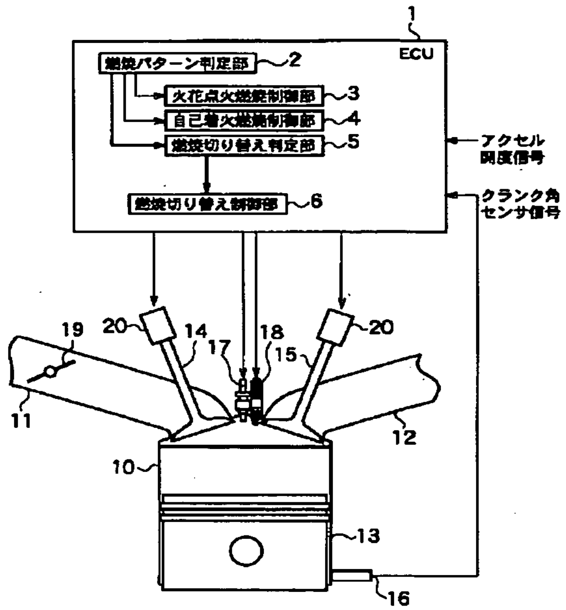
【図８】


大
負荷
小
火花点火燃焼
(均質)
圧縮自己着火燃焼
(均質)
火花点火燃焼
(均質)
定常
火花点火燃焼
(均質)
圧縮自己着火燃焼
(均質)
圧縮自己着火燃焼
(成層)
火花点火燃焼
(成層)
火花点火燃焼
(均質)
燃焼切り替え
過渡

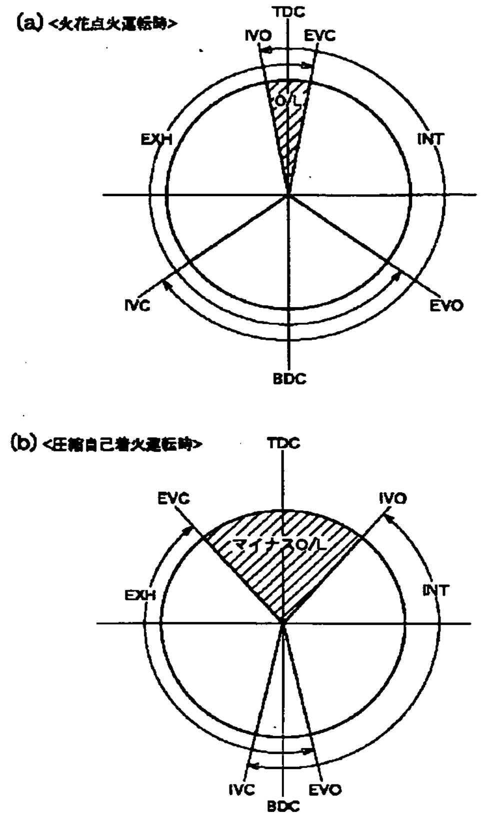
【図９】


START
S11
エンジン回転数N、負荷T検出
S12
燃焼パターン判断
火花点火
切り替え
自己着火
S13
火花点火燃焼
制御開始
S14
自己着火燃焼
制御開始
S15
切り替え燃焼
制御開始
RETURN

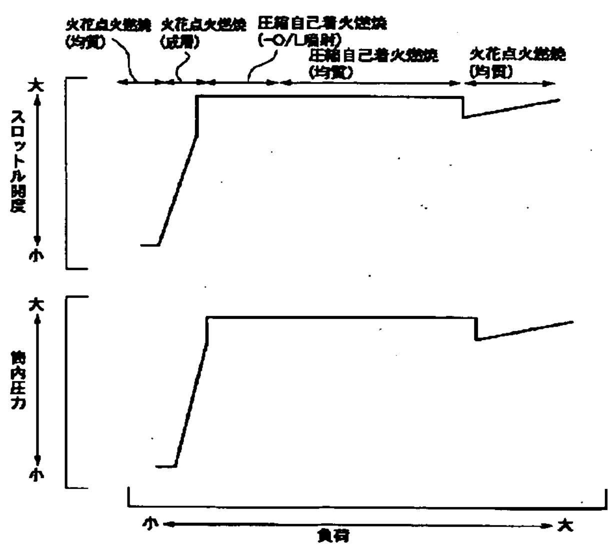
【図１２】



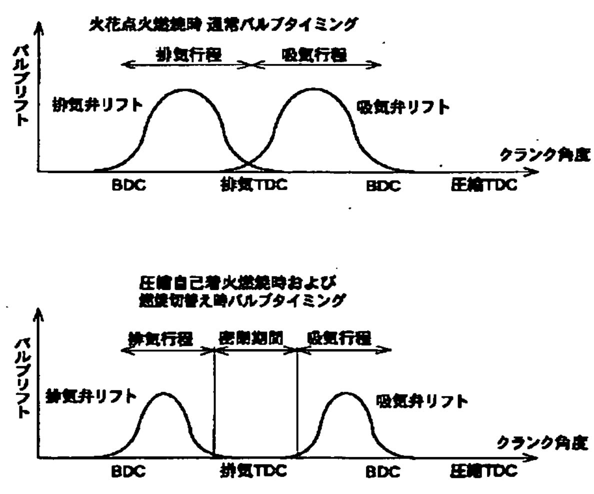
【図１３】



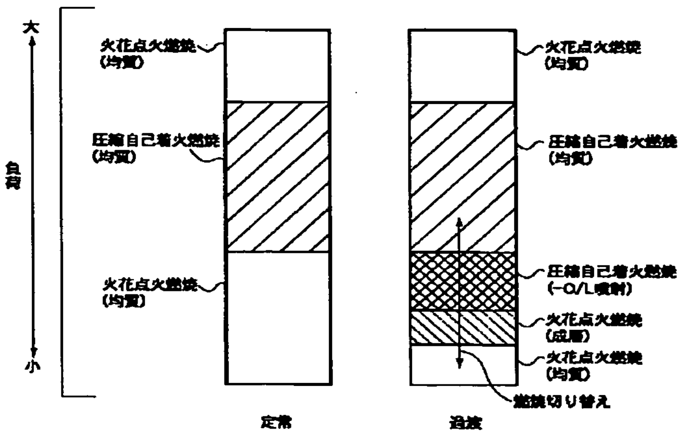
【図１４】



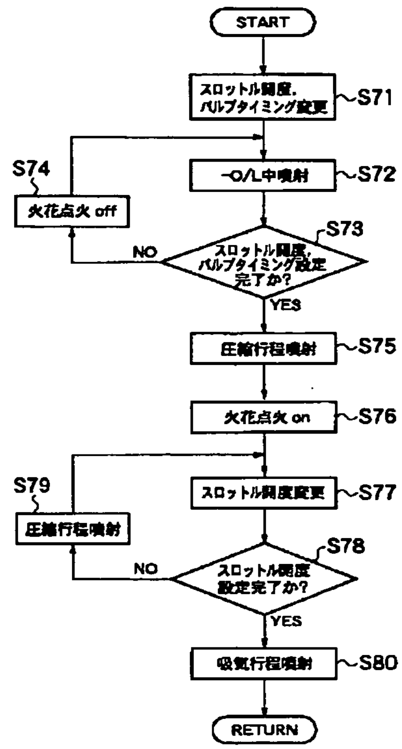
【図１９】



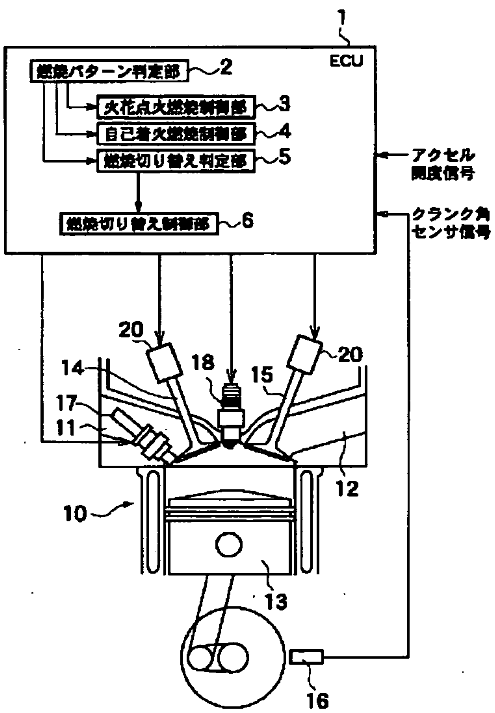
【図１５】



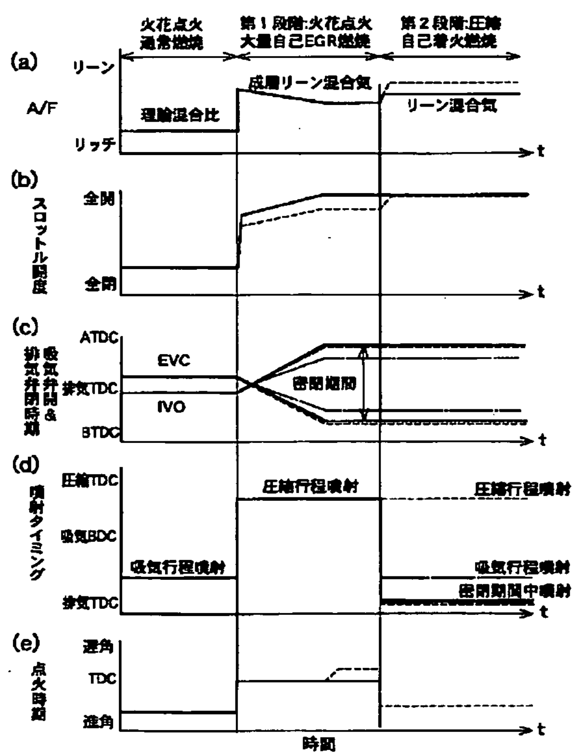
【図１７】



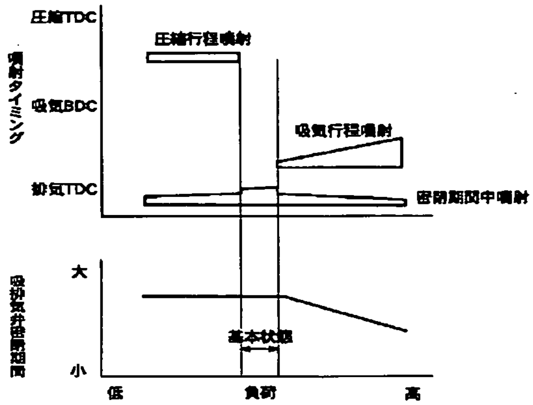
【図１８】



【図２１】



【図２２】



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	17/00			17/00	Ｆ
	41/02	３０１		41/02	３０１Ａ
		３５１			３５１
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					３０１Ｚ
					３０１Ｊ
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					Ｂ

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the compressed self-ignition type gasoline engine which changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by the service condition.
[0002]
[Description of the Prior Art] Since combustion is started by the multipoint of a combustion chamber, compressed self-ignition combustion has the quick rate of combustion, and since the combustion by which the air-fuel ratio was stabilized also in the Lean condition compared with the usual jump-spark-ignition combustion is realizable, and and combustion temperature falls possible [improvement in specific fuel consumption], it can also reduce NOx in exhaust gas sharply. [an air-fuel ratio] Moreover, if a fuel and air are fully premixed, an air-fuel ratio will become more uniform, and it is NOx further. It can decrease.
[0003] Moreover, high rotation, high power reservation at the time of a heavy load, and coexistence of low rotation, the improvement in specific fuel consumption at the time of the load in low, and reduction-izing of NOx can be aimed at by making the usual jump-spark-ignition combustion perform in high rotation and a heavy load field, and changing a combustion gestalt from jump-spark-ignition combustion to compressed self-ignition combustion in low rotation and the load field in low.
[0004] However, in order to attain temperature of gaseous mixture whose compressed self-ignition combustion is attained, and a pressure, in the case where an engine's base compression ratio is raised, knocking occurs at the time of jump-spark-ignition combustion. If an inhalation air content is reduced or lag-ization of ignition timing is performed in order to avoid knocking, the problem that the fall of specific power is not avoided will arise.
[0005] Then, as a method of realizing compressed self-ignition combustion, without raising an engine's base compression ratio too much, at both the times of compressed self-ignition combustion, an induction-exhaust valve serves as close near exhaust air TDC, and the way internal EGR performs inhalation-of-air heating by establishing the sealing period which seals a combustion chamber is proposed (for example, JP,10-252512,A).
[0006] However, the conventional technology is premised on carrying out compressed self-ignition operation of all the operating range, and is not mentioned about the dynamic change under engine operation with jump-spark-ignition combustion operation and compressed self-ignition combustion operation.
[0007] Moreover, a cam shaft is equipped with two or more cams from which a profile differs as conventional technology which changes the closing motion stage or the amount of lifts of an induction-exhaust valve, and the mechanical-cable-type adjustable valve gear which changes the condition of the engagement lever of the rocker arm which counters each cam at a hydraulic-drive piston is known (for example, JP,9-203307,A).
[0008] According to this mechanical-cable-type adjustable valve gear, by the time the change to a rocker

arm which is different from actuation of a hydraulic control valve was completed, the number cycle important point was carried out in the combustion cycle.
[0009]
[Problem(s) to be Solved by the Invention] When generating compressed self-ignition combustion with inhalation-of-air heating by self-EGR, in the combustion cycle which ranks second to the last spark ignition combustion cycle, the increment in the specified quantity of the amount of self-EGR(s) must be carried out, and compressed self-ignition combustion must be generated certainly. If compressed self-ignition combustion is inadequate in the following combustion cycle, the temperature in a cylinder and a pressure will decline and compressed self-ignition will become difficult further.
[0010] However, by the responsibility of the conventional mechanical-cable-type adjustable valve gear, in order for conversion in the amount of self-EGR(s) demanded by compressed self-ignition combustion to take a number cycle, when the amount of self-EGR(s) was made to increase beforehand before a combustion change, there was a trouble that knocking occurred in jump-spark-ignition combustion.
[0011] to a ****** case, compressed self-ignition combustion has the unstable increment in the amount of self-EGR(s) on the contrary -- becoming -- self -- since the quantity of heat by EGR decreased, there was a trouble that the return of the stable compressed self-ignition combustion was difficult.
[0012] Moreover, on the occasion of the change to the jump-spark-ignition combustion from compressed self-ignition combustion, when there were many amounts of self-EGR(s), the temperature in a cylinder became high at reverse, and there was a trouble that knocking occurred at the time of jump-spark-ignition combustion.
[0013] In order to prevent knocking at the time of jump-spark-ignition combustion on the contrary, when the amount of self-EGR(s) was reduced beforehand, there was a trouble that the compressed self-ignition combustion before a change became unstable.
[0014] In addition to said trouble, by the change of jump-spark-ignition combustion operation and compressed self-ignition combustion operation, it is carried out by two or more service conditions, and inhalation negative pressure may be changed depending on conditions. In this case, since there is response delay also in modification of a pressure, a number cycle important point will be carried out to that setup.
[0015] Therefore, on the occasion of the change to compressed self-ignition combustion operation from jump-spark-ignition combustion operation, since cylinder internal pressure is low, compressed self-ignition combustion becomes unstable. Moreover, on the occasion of the change to the jump-spark-ignition combustion from compressed self-ignition combustion, since cylinder internal pressure was high, the trouble that knocking occurred at the time of jump-spark-ignition combustion was in reverse.
[0016] Moreover, since the change of jump-spark-ignition combustion operation and compressed self-ignition combustion operation was performed by two or more service conditions as mentioned above, when control suitable for each change conditions was not performed, there was a trouble that combustion instability and knocking occurred.
[0017] This invention is what took the example by this trouble, and the purpose is in offering the compressed self-ignition type gasoline engine which can do the stable change in a low load operating range, controlling generating of combustion instability or knocking at the time of the change to compressed self-ignition combustion operation from jump-spark-ignition combustion operation, or the change to jump-spark-ignition combustion operation from compressed self-ignition combustion operation.
[0018] Moreover, this invention is to offer the compressed self-ignition type gasoline engine which can do the change to the stable compressed self-ignition combustion, inhibiting generating of knocking, when the mechanical-cable-type adjustable valve gear whose responsibility is not necessarily high is used.
[0019]
[Means for Solving the Problem] In order that invention according to claim 1 may solve the above-mentioned technical problem, a combustion chamber equips with the injection valve in a cylinder which injects a direct fuel, and in case a combustion change is carried out to compressed-self-ignition

combustion operation from jump-spark-ignition combustion operation in a compressed-self-ignition type gasoline engine which changes dynamically jump-spark-ignition combustion and compressed-self-ignition combustion by service condition, after carrying out jump-spark-ignition combustion of a stratification condition that jump-spark-ignition combustion performs fuel injection into a compression stroke, it carries out starting compressed-self-ignition combustion as a summary.

[0020] In order that invention according to claim 2 may solve the above-mentioned technical problem, in case a combustion change is carried out to jump-spark-ignition combustion operation from compressed self-ignition combustion operation, in a compressed self-ignition type gasoline engine according to claim 1, jump-spark-ignition combustion makes it a summary to perform jump-spark-ignition combustion in a stratification condition of performing fuel injection into a compression stroke first.

[0021] In order that invention according to claim 3 may solve the above-mentioned technical problem, a combustion chamber is equipped with an injection valve in a cylinder which injects a direct fuel, and in case a combustion change is carried out to compressed self-ignition combustion operation from jump-spark-ignition combustion operation in a compressed self-ignition type gasoline engine which changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by service condition, it carries out that compressed-self-ignition combustion carries out compressed-self-ignition combustion in a stratification condition of performing fuel injection into a compression stroke first as a summary.

[0022] In order to solve the above-mentioned technical problem, in case invention according to claim 4 carries out a combustion change to jump-spark-ignition combustion operation from compressed self-ignition combustion operation, after it performs compressed self-ignition combustion in a stratification condition of performing fuel injection into a compression stroke at the time of compressed self-ignition combustion, it makes it a summary to perform jump-spark-ignition combustion in a compressed self-ignition type gasoline engine according to claim 3.

[0023] A combustion chamber is equipped with a closing motion stage adjustable means to change the closing motion stage of an injection valve in a cylinder, and an induction-exhaust valve to inject a direct fuel in order that invention according to claim 5 may solve the above-mentioned technical problem. In a compressed self-ignition type gasoline engine which changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by service condition In case it changes from jump-spark-ignition combustion to compressed self-ignition combustion, a sealing period which both induction-exhaust valves closed near the compression top dead center with said closing motion stage adjustable means is established, and compressed self-ignition combustion makes it a summary to perform compressed self-ignition combustion which performs fuel injection during said sealing period first.

[0024] In order to solve the above-mentioned technical problem, invention according to claim 6 makes it a summary to perform jump-spark-ignition combustion in a compressed self-ignition type gasoline engine according to claim 5, after performing compressed self-ignition combustion which performs fuel injection during said sealing period, in case it changes from compressed self-ignition combustion to jump-spark-ignition combustion.

[0025] In a compressed self-ignition type gasoline engine which equips a combustion chamber with an injection valve in a cylinder which injects a direct fuel, and changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by service condition in order that invention according to claim 7 may solve the above-mentioned technical problem In case a combustion change is carried out to compressed self-ignition combustion operation from jump-spark-ignition combustion operation Let it be a summary to perform compressed self-ignition combustion in a stratification condition that start compressed self-ignition combustion and compressed self-ignition combustion performs fuel injection into a compression stroke first after performing jump-spark-ignition combustion in a stratification condition that jump-spark-ignition combustion performs fuel injection into a compression stroke.

[0026] In order that invention according to claim 8 may solve the above-mentioned technical problem,

in case a combustion change is carried out to compressed-self-ignition combustion operation from compressed-self-ignition combustion operation, it carries out carrying out jump-spark-ignition combustion of a stratification condition that start jump-spark-ignition combustion and jump-spark-ignition combustion performs fuel injection into a compression stroke first after performing compressed-self-ignition combustion in a stratification condition that compressed-self-ignition combustion performs fuel injection into a compression stroke as a summary in a compressed-self-ignition type gasoline engine according to claim 7.

[0027] A combustion chamber is equipped with a closing motion stage adjustable means to change the closing motion stage of an injection valve in a cylinder, and an induction-exhaust valve to inject a direct fuel in order that invention according to claim 9 may solve the above-mentioned technical problem. In a compressed self-ignition type gasoline engine which changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by service condition In case it changes from jump-spark-ignition combustion to compressed self-ignition combustion, a sealing period which both induction-exhaust valves closed near the compression top dead center with said closing motion stage adjustable means is established. After performing jump-spark-ignition combustion in a stratification condition of performing fuel injection into a compression stroke, compressed self-ignition combustion is started and compressed self-ignition combustion makes it a summary to perform compressed self-ignition combustion which performs fuel injection during said sealing period first.

[0028] In order that invention according to claim 10 may solve the above-mentioned technical problem, let it be a summary to perform jump-spark-ignition combustion and for jump-spark-ignition combustion to perform jump-spark-ignition combustion in a stratification condition of performing fuel injection into a compression stroke first after performing compressed self-ignition combustion to which compressed self-ignition combustion carries out fuel injection during said sealing period, in case it changes from compressed self-ignition combustion to jump-spark-ignition combustion in a compressed self-ignition type gasoline engine according to claim 9.

[0029] In order that invention according to claim 11 may solve the above-mentioned technical problem, in a compressed self-ignition type gasoline engine given in any 1 term of claims 1, 3, 5, 7, and 9, ignition timing in front of a change to compressed self-ignition combustion from said jump-spark-ignition combustion makes it a summary to carry out a lag to ignition timing of a steady state in the same engine rotational frequency and the same load conditions.

[0030] In order to solve the above-mentioned technical problem, in a compressed self-ignition type gasoline engine according to claim 11, invention according to claim 12 discharges from said jump-spark-ignition combustion to an ignition plug to compressed self-ignition combustion after a change and near before [a compression top dead center] 30 degree, promotes compressed self-ignition, and makes it a summary to stop jump spark ignition after initiation of compressed self-ignition combustion.

[0031] In order to solve the above-mentioned technical problem, invention according to claim 13 makes it a summary to inject the remainder of a fuel in a compression stroke or an intake stroke according to an engine's load in a compressed self-ignition type gasoline engine according to claim 5 or 9 while injecting some fuels during said sealing period at the time of a change to compressed self-ignition combustion from said jump-spark-ignition combustion.

[0032] Invention according to claim 14 makes it a summary to have increased the quantity of fuel quantity injected during said sealing period to the time of the usual compressed self-ignition combustion at the time of a change to compressed self-ignition combustion from said jump-spark-ignition combustion in a compressed self-ignition type gasoline engine according to claim 13, in order to solve the above-mentioned technical problem.

[0033] In a compressed self-ignition type gasoline engine given in any 1 term of claims 5, 9, 11, 12, 13, and 14 in order that invention according to claim 15 may solve the above-mentioned technical problem At the time of a change to compressed self-ignition combustion from said jump-spark-ignition combustion, a low load side considers the length of said sealing period as abbreviation regularity according to a load at the time of a combustion change, and let it be a summary to decrease the length of said sealing period according to an increment in a load from a place beyond a predetermined load.

[0034] Invention according to claim 16 makes it a summary to divide into at least two or more groups a gas column which performs a combustion change, to shift time amount among groups, and to change sequential combustion at the time of a change to compressed self-ignition combustion from said jump-spark-ignition combustion, in a compressed self-ignition type gasoline engine of claim 1 thru/or claim 15 given in any 1 term, in order to solve the above-mentioned technical problem.
[0035]
[Effect of the Invention] According to this invention according to claim 1, in case the dynamic change to compressed self-ignition combustion operation from jump-spark-ignition combustion operation is performed, jump-spark-ignition combustion performs jump-spark-ignition combustion in the stratification condition of performing fuel injection into a compression stroke. By this, since cylinder internal pressure at the time of the change to the compressed self-ignition combustion from jump-spark-ignition combustion can be made high, the combustion at the time of compressed self-ignition combustion can be stabilized. Consequently, it can change at the time of operation, the combustion instability at the time can be controlled, and it is effective in the ability to prevent aggravation of operability.
[0036] According to this invention according to claim 2, in case the dynamic change to jump-spark-ignition combustion operation from compressed self-ignition combustion operation is performed, jump-spark-ignition combustion performs jump-spark-ignition combustion in the stratification condition of performing fuel injection into a compression stroke. By this, to the case where jump-spark-ignition operation of homogeneity is performed, the increment in the fuel quantity at the time of jump-spark-ignition operation can be controlled, and generating of knocking at the time of jump-spark-ignition combustion can be prevented. Consequently, it can change at the time of operation, knocking at the time can be controlled, and it is effective in the ability to prevent aggravation of operability.
[0037] According to this invention according to claim 3, in case the dynamic change to compressed self-ignition combustion operation from jump-spark-ignition combustion operation is performed, compressed self-ignition combustion performs compressed self-ignition combustion in the stratification condition of performing fuel injection into a compression stroke. By this, since the ignitionability at the time of compressed self-ignition combustion is improvable, the combustion at the time of compressed self-ignition combustion can be stabilized. Consequently, it can change at the time of operation, the combustion instability at the time can be controlled, and it is effective in the ability to prevent aggravation of operability.
[0038] According to this invention according to claim 4, in case the dynamic change to jump-spark-ignition combustion operation from compressed self-ignition combustion operation is performed, compressed self-ignition combustion performs compressed self-ignition combustion in the stratification condition of performing fuel injection into a compression stroke. By this, since the ignitionability at the time of compressed self-ignition combustion is improvable, fuel oil consumption of the jump-spark-ignition combustion after a combustion change can be lessened, and knocking can be prevented. Consequently, it can change at the time of operation, knocking at the time can be controlled, and it is effective in the ability to prevent aggravation of operability.
[0039] So that it may have the sealing period when both inhalation of air and an exhaust valve closed near the exhaust air top dead center at, and the combustion chamber was sealed, in case the dynamic change to compressed self-ignition combustion operation from jump-spark-ignition combustion operation is performed according to this invention according to claim 5 Since the combustion condition was changed from jump-spark-ignition combustion operation to compressed self-ignition combustion by changing the closing motion stage of an induction-exhaust valve, and injecting a fuel during said sealing period Even if the responsibility of a closing motion change of the induction-exhaust valve by the closing motion stage adjustable means is late, it is effective in the ability to change from jump-spark-ignition combustion to compressed self-ignition combustion certainly in 1 combustion cycle.
[0040] According to this invention according to claim 6, when performing the dynamic change to jump-spark-ignition combustion operation from compressed self-ignition combustion operation, the closing motion stage of an induction-exhaust valve is changed, and the jump-spark-ignition combustion

condition was changed from compressed self-ignition combustion operation by injecting a fuel during said sealing period so that it might have the sealing period when both inhalation of air and an exhaust valve serve as close near an exhaust air top dead center. By this, since the load at the time of compressed self-ignition combustion can be fallen, fuel oil consumption of the jump-spark-ignition combustion after a combustion change can be lessened, and knocking can be prevented. Consequently, it can change at the time of operation, knocking at the time can be controlled, and it is effective in the ability to prevent aggravation of operability.

[0041] According to this invention according to claim 7, in case the dynamic change to compressed self-ignition combustion operation from jump-spark-ignition combustion operation is performed, jump-spark-ignition combustion in the stratification condition of performing fuel injection into a compression stroke is performed at the time of jump-spark-ignition combustion, and compressed self-ignition combustion performs compressed self-ignition combustion in the stratification condition of performing fuel injection into a compression stroke. By this, since cylinder internal pressure at the time of the change to the compressed self-ignition combustion from jump-spark-ignition combustion can be made high, the combustion at the time of compressed self-ignition combustion can be stabilized. Furthermore, since the ignitionability at the time of compressed self-ignition combustion is improvable, the combustion at the time of compressed self-ignition combustion can be stabilized. Consequently, it can change at the time of operation, the combustion instability at the time can be controlled, and it is effective in the ability to prevent aggravation of operability.

[0042] According to this invention according to claim 8, in case the dynamic change to jump-spark-ignition combustion operation from compressed self-ignition combustion operation is performed, compressed self-ignition combustion performs compressed self-ignition combustion in the stratification condition of performing fuel injection into a compression stroke, and jump-spark-ignition combustion in the stratification condition of performing fuel injection into a compression stroke is performed at the time of jump-spark-ignition combustion. By this, since the load at the time of compressed self-ignition combustion can be fallen, fuel oil consumption of the jump-spark-ignition combustion after a combustion change can be lessened, and knocking can be prevented. Consequently, it can change at the time of operation, knocking at the time can be controlled, and aggravation of operability can be prevented. Furthermore, to the case where jump-spark-ignition operation of homogeneity is performed, the increment in the fuel quantity at the time of jump-spark-ignition operation can be controlled, and generating of knocking at the time of jump-spark-ignition combustion can be prevented. Consequently, it can change at the time of operation, knocking at the time can be controlled, and it is effective in the ability to prevent aggravation of operability.

[0043] While according to this invention according to claim 9 changing a closing motion stage so that it may have the sealing period when both an inlet valve and an exhaust valve serve as close near an exhaust air top dead center in case it changes from jump-spark-ignition combustion operation to compressed self-ignition combustion operation Since combustion was changed from jump-spark-ignition combustion to compressed self-ignition combustion operation by injecting a fuel during said sealing period after performing stratification combustion by jump spark ignition, it is effective in the ability to perform little smooth combustion change of torque fluctuation also in a low torque field.

[0044] While according to this invention according to claim 10 changing a closing motion stage so that it may have the sealing period when both an inlet valve and an exhaust valve serve as close near an exhaust air top dead center in case it changes from compressed self-ignition combustion operation to jump-spark-ignition combustion operation, after performing compressed self-ignition combustion which injects a fuel during said sealing period, jump-spark-ignition combustion of a stratification condition is performed. Thereby, since the load at the time of compressed self-ignition combustion can be fallen, fuel oil consumption of the jump-spark-ignition combustion after a combustion change can be lessened, and knocking can be prevented. Furthermore, to the case where jump-spark-ignition operation of homogeneity is performed, the increment in the fuel quantity at the time of jump-spark-ignition operation can be controlled, and generating of knocking at the time of jump-spark-ignition combustion can be prevented. Consequently, it can change at the time of operation, knocking at the time can be

controlled, and it is effective in the ability to prevent aggravation of operability.
[0045] According to this invention according to claim 11, since it was made to carry out the lag of the ignition timing in front of the change to the compressed self-ignition combustion from jump-spark-ignition combustion to the ignition timing of the steady state in the same engine rotational frequency and the same load conditions, the generating stage of heat of combustion is delayed, a burnt gas with a high temperature is used for internal EGR, and it is effective in the ability to make compressed self-ignition cause easily.
[0046] According to this invention according to claim 12, it is effective in reforming of the fuel being carried out by the radical generated by discharge near before [a compression top dead center] 30 degree, and being able to make compressed self-ignition cause easily from an ignition plug at the time of the compressed self-ignition combustion initiation after a combustion change.
[0047] Since according to this invention according to claim 13 the remaining fuel was injected in the compression stroke or the intake stroke according to the load of a period at the time of the change to the compressed self-ignition combustion from jump-spark-ignition combustion while injecting some fuels during the sealing period, fuel reforming performed in a compression process can be performed without excess and deficiency, and there is an effect of making compressed self-ignition cause stably.
[0048] Since it was made to increase the quantity of the fuel quantity injected during a sealing period to the time of the usual compressed self-ignition combustion at the time of the change to the compressed self-ignition combustion from jump-spark-ignition combustion according to this invention according to claim 14, it is effective in the ability to strengthen fuel reforming and raise further the combustion stability of a compressed self-ignition start point.
[0049] According to this invention according to claim 15, at the time of the change to the compressed self-ignition combustion from jump-spark-ignition combustion Since it was made to decrease the length of a sealing period according to the increment in a load from the place which the low load side considered the length of a sealing period as abbreviation regularity according to the load at the time of a combustion change, and exceeded the predetermined load While securing the fuel reforming time amount at the time of a low load, it is effective in the ability to prevent that fuel reforming progresses too much at the time of a heavy load, and knocking occurs.
[0050] Since according to this invention according to claim 16 the gas column which performs a combustion change is divided into at least two or more groups, time amount is shifted among groups and it was made to change sequential combustion at the time of the change to the compressed self-ignition combustion from jump-spark-ignition combustion, it is effective in the ability to control enough the engine torque fluctuation at the time of the change to the compressed self-ignition combustion from jump-spark-ignition combustion.
[0051]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained based on a drawing. Drawing 1 is system configuration drawing showing the configuration [of the compressed self-ignition gasoline internal combustion engine concerning this invention] of the 1st of the gestalt of operation.
[0052] In this operation gestalt, it is dynamically switchable during engine operation in compressed self-ignition combustion and jump-spark-ignition combustion according to a service condition. The engine 10 in drawing is equipped with a suction port 11, the exhaust air port 12, the bis-ton 13, an intake valve 14, the exhaust air bulb 15, the crank angle sensor 16, the fuel injection equipment 17, the ignition plug 18, and the throttle valve 19.
[0053] The electronic control (it abbreviates to ECU hereafter) 1 which controls this engine 10 The combustion pattern judging section 2 which judges whether it operates according to a service condition by either combustion system of compressed self-ignition combustion and jump-spark-ignition combustion, The jump-spark-ignition combustion-control section 3 which controls the combustion parameter at the time of jump-spark-ignition combustion operation, The self-ignition combustion-control section 4 which controls the combustion-control parameter at the time of compressed self-ignition combustion operation, It has the combustion change judging section 5 the change to compressed

self-ignition combustion and jump-spark-ignition combustion judges [necessity or] whether it is unnecessary to be, and the combustion change control section 6 which controls combustion fuel injection timing, fuel oil consumption, and ignition timing, and realizes a smooth combustion change when a combustion change is required.

[0054] In addition, the combustion pattern judging section 2 which is the component of ECU1, the jump-spark-ignition combustion-control section 3, the self-ignition combustion-control section 4, the combustion change judging section 5, and the combustion change control section 6 are realized as a program of a microcomputer.

[0055] Moreover, based on the engine speed signal which the crank angle sensor 16 detected, and the accelerator opening signal (load) which the accelerator opening sensor (not shown) detected, ECU1 judges a service condition and judges a combustion pattern. Moreover, according to a service condition, fuel oil consumption, fuel injection timing, and ignition timing are computed. And based on this calculation result, a signal is sent to a fuel injection equipment 17 and an ignition plug 18.

[0056] moreover, although there are not the throttle valve 19 for air content adjustment and a drawing example, the inhalation-of-air system which consists of the air flow meter, the air cleaner, and piping for air content measurement is prepared in the upstream of a suction port 11.

[0057] With the basis of such a configuration, and this operation gestalt, compressed self-ignition combustion is performed in the specific service condition of low rotation as shown in drawing 2 , and the load in low, and jump-spark-ignition combustion is performed in a super-low load, a heavy load, or a high rotation region.

[0058] Next, actuation of the 1st operation gestalt is explained. Drawing 3 shows the range where the self-ignition combustion to an air-fuel ratio is materialized. Fuel injection is performed from the top dead center at the stage which fully carried out the tooth lead angle, and gaseous mixture is in the premixing condition. If the air-fuel ratio is made into Lean, combustion stability will get worse and an engine's torque fluctuation will become large. For this reason, the air-fuel ratio AFL from which stability permissible as the layout value as an internal combustion engine or character of vehicles in which this internal combustion engine was carried serves as the stability threshold value Sth serves as the Lean limit.

[0059] On the other hand, if the air-fuel ratio is made rich, knocking reinforcement will increase. Thereby, the air-fuel ratio AFR in the knocking limit Nth serves as a rich limit. Therefore, the air-fuel ratio field surrounded with the stability marginal air-fuel ratio AFL and the knocking marginal air-fuel ratio AFR serves as a self-ignition combustion formation range.

[0060] Thus, self-ignition is materialized only in the limited air-fuel ratio range. In addition, air-fuel ratio A/F was explained to the example as an index with which the rate of gas and a fuel is expressed here. The same orientation is shown also about the case where residual gas or EGR gas is contained, and a horizontal axis serves as the total capacity and fuel rate G/F which doubled the burnt gas with new mind in this case.

[0061] Although drawing 3 showed the self-ignition combustion formation range to an air-fuel ratio as a combustion parameter, the same orientation is shown also to temperature, an intake pressure, or charge pressure besides an air-fuel ratio. That is, if temperature falls, combustion stability will get worse, and if temperature rises, knocking reinforcement will increase. Moreover, if a pressure declines also about an intake pressure and charge pressure, combustion stability will get worse, and if a pressure increases, knocking reinforcement will increase. Therefore, in order to maintain the stable self-ignition combustion, it is necessary to control the temperature demanded and a pressure.

[0062] Drawing 4 shows the conditions to which self-ignition combustion operation changes from jump-spark-ignition combustion operation in the 1st operation gestalt. As shown in drawing 4 , two kinds of changes of a combustion pattern exist. It is the case where it changes from jump-spark-ignition combustion to the case where it changes from compressed self-ignition combustion or compressed self-ignition combustion to jump-spark-ignition combustion in a heavy load region at compressed self-ignition combustion, from the jump-spark-ignition combustion from compressed self-ignition combustion, or jump-spark-ignition combustion in a low load region.

[0063] This invention is the thing of an about when a combustion gestalt changes in a low load region. The throttle opening to a load and cylinder internal pressure are shown in drawing 5 . Jump-spark-ignition combustion is SUTOIKI combustion of homogeneity. When a combustion gestalt changes from jump-spark-ignition combustion to compressed self-ignition combustion in a low load region, throttle opening differs greatly. For this reason, cylinder internal pressure will differ greatly. For this reason, when a combustion gestalt changes to compressed self-ignition combustion, cylinder internal pressure may be insufficient, and combustion may become unstable as mentioned above.
[0064] The throttle opening to a load and cylinder internal pressure at the time of considering jump-spark-ignition combustion as stratification combustion in a low load region are shown in drawing 6 . Since Lean can do an air-fuel ratio, with an air content enlarged in performing stratification combustion, throttle opening can be enlarged. Therefore, cylinder internal pressure can also be kept high compared with homogeneity SUTOIKI combustion. For this reason, since it is made to desired value in time amount with short cylinder internal pressure when changing a combustion condition, it can prevent that combustion becomes unstable.
[0065] The throttle opening to a load and cylinder internal pressure at the time of performing stratification combustion to drawing 7 at the time of compressed self-ignition combustion are shown. When stratification combustion is performed at the time of compressed self-ignition combustion,-izing of the load whose compressed self-ignition combustion is attained can be carried out [a low load]. For this reason, the load which performs a combustion change will also be formed into a low load. Since the burning fuel quantity decreases when the low load of the load which performs a combustion change is carried out, jump-spark-ignition combustion and compressed self-ignition combustion lifting-come to be hard of knocking. That is, there is little fuel quantity which burns since the load is low, and its calorific value at the time of combustion decreases. Therefore, when combustion parameters, such as cylinder internal pressure and temperature, shift from desired value at the time of a combustion change, it is hard to cause knocking.
[0066] The combustion gestalt when changing a combustion condition to drawing 8 is shown. When the engine is operating steadily, jump-spark-ignition combustion of SUTOIKI homogeneity is performed at the time of a super-low load. Compressed self-ignition combustion of homogeneity is performed at the time of an inside load. Sequentially from a low load, jump-spark-ignition combustion of SUTOIKI homogeneity is performed in the transient from which a load changes, then, jump-spark-ignition combustion of stratification is performed to it, then, compressed self-ignition combustion of stratification is performed to it, and, finally compressed self-ignition combustion of homogeneity is performed to it.
[0067] The change control flow explained above is explained with reference to a flow chart. The Maine flow chart which controls a combustion pattern to drawing 9 is shown. Engine-speed N and Load T are detected at step 11 (henceforth, S11). Subsequently, the combustion pattern according to a service condition is judged from the map of drawing 3 by S12. When judged as jump-spark-ignition combustion, a jump-spark-ignition combustion control is started by S13. When judged as self-ignition combustion, a self-ignition combustion control is started by S14. When judged as a combustion change, combustion change control is started by S15.
[0068] The control flow chart in the case of changing combustion from jump-spark-ignition combustion to drawing 10 at compressed self-ignition combustion is shown. First, throttle opening is changed by S21. Subsequently, throttle opening judges whether it is set as the desired value shown in drawing 6 by S22. When the setup of throttle opening is not completed, in order to continue homogeneity combustion of SUTOIKI, intake-stroke injection is continued by S23. When it is judged that a setup of throttle opening was completed by S22, compression stroke injection is performed by S24, and jump-spark-ignition combustion of a stratification condition is performed.
[0069] Subsequently, throttle opening is again changed by S25. Throttle opening judges whether it is set as the desired value shown in drawing 6 by S26. When the setup of throttle opening is not completed, in order to continue jump-spark-ignition combustion, jump spark ignition is performed by S27. When it is judged that a setup of throttle opening was completed by S26, jump spark ignition is turned off by S28,

and compressed self-ignition combustion is started. The homogeneity calorific-capacity-of-combustion-chamber field which an engine's load shows to the graph of drawing 8 by S29 judges in how. In not being a homogeneity combustion zone, compression stroke injection is performed by S30, and it performs compressed self-ignition combustion of a stratification condition. When judged as a homogeneity calorific-capacity-of-combustion-chamber field by S29, intake-stroke injection is performed by S31, and compressed self-ignition combustion of a homogeneity condition is started.
[0070] The control flow chart in the case of changing combustion from compressed self-ignition combustion to drawing 11 at jump-spark-ignition combustion is shown. When judged as a combustion change with the flow chart of drawing 9 , compression stroke injection is first performed by S41, and compressed self-ignition combustion of a stratification condition is started. It judges whether it is set as the desired value which changes throttle opening by S42 and throttle opening shows to drawing 6 by S43. When the setup of throttle opening is not completed, compressed self-ignition combustion is continued using jump spark ignition as off by S44. When it is judged that a setup of throttle opening was completed by S43, jump-spark-ignition combustion is started by setting jump spark ignition to ON by S45.
[0071] Subsequently, throttle opening is again changed by S46. It judges whether it is set as the desired value shown in drawing 6 by S47. When not set as desired value, compression stroke injection is performed by S48, and stratification condition jump-spark-ignition combustion is continued. When it is judged that a setup of throttle opening is completed by S47, intake-stroke injection is performed by S49, and jump-spark-ignition combustion of a homogeneity condition is started.
[0072] Next, the gestalt of the 2nd operation is explained. Drawing 12 is system configuration drawing showing the configuration [of the compressed self-ignition type gasoline engine concerning this invention] of the 2nd of the gestalt of operation. The gestalt of the 2nd operation has the composition of having added the adjustable valve timing device 20 in which the closing motion stage of an induction-exhaust valve was changed, to the gestalt of the 1st operation. As an adjustable valve timing device, technology given in JP,10-266878,A can be used, for example.
[0073] The closing motion timing of the induction-exhaust valve of this operation gestalt is shown in drawing 13 . At the time of jump-spark-ignition operation, the clausilium stage (EVC) of an exhaust air bulb (EXH) and the valve-opening stage (IVO) of an intake valve (INT) serve as near a piston top dead center (TDC) like the usual four-cycle gasoline engine, and it is set as necessary bulb overlap (O/L).
[0074] At the time of compressed self-ignition operation in a specific operating range at the time of changing a combustion condition While an exhaust air bulb close stage (EVO) carries out a tooth lead angle and closes the valve to jump-spark-ignition operation in the middle of an intake stroke It is controlled so that an intake valve open stage (IVO) carries out a lag and opens in the middle of an intake stroke, and the bulb overlap in near a piston top dead center does not exist at all, but is set as the minus overlap (-O/L) condition which is the sealing period which sealed the combustion chamber.
[0075] Thus, by considering as the valve timing which constitutes minus overlap at the time of compressed self-ignition operation, an exhaust air bulb makes the hot burnt gas which is opened in exhaust stroke halfway and is equivalent to the volume of combustion chamber in the time pile up in a combustion chamber, and considers as the internal EGR gas to degree cycle. In degree cycle, an intake valve opens in the middle of an intake stroke, and new mind is inhaled. In response to the quantity of heat from internal EGR gas, the temperature in a cylinder will carry out the temperature up of the new mind here.
[0076] If fuel injection is performed into -O/L here, reforming of the fuel will be carried out in response to the quantity of heat from the hot gas shut up in the cylinder. Consequently, the ignitionability of a fuel is improved and compressed self-ignition combustion on low load conditions is attained more.
[0077] The throttle opening to a load and cylinder internal pressure at the time of performing compressed self-ignition combustion by -O/L injection to drawing 14 at the time of a low load are shown. Compared with drawing 7 , the compressed self-ignition combustion in low load conditions is more possible. For this reason, the load which performs a combustion change will also be formed into a low load. Since the burning fuel quantity decreases when the low load of the load which performs a

combustion change is carried out, jump-spark-ignition combustion and compressed self-ignition combustion lifting-come to be hard of knocking. That is, there is little fuel quantity which burns since the load is low, and its calorific value at the time of combustion decreases. Therefore, when combustion parameters, such as cylinder internal pressure and temperature, shift from desired value at the time of a combustion change, it is hard to cause knocking.

[0078] The combustion gestalt when changing a combustion condition to drawing 15 is shown. When the engine is operating steadily, jump-spark-ignition combustion of SUTOIKI homogeneity is performed at the time of a super-low load. Compressed self-ignition combustion of homogeneity is performed at the time of an inside load. Sequentially from a low load, jump-spark-ignition combustion of SUTOIKI homogeneity is performed in the transient which carries out a change of load, then, jump-spark-ignition combustion of stratification is performed to it, then, compressed self-ignition combustion of injection among -O/L is performed to it, and, finally compressed self-ignition combustion of homogeneity is performed to it.

[0079] The flow chart which controls a combustion pattern is the same as the 1st operation gestalt (drawing 9).

[0080] The control flow chart in the case of changing combustion from jump-spark-ignition combustion to drawing 16 at compressed self-ignition combustion is shown. Only a different place from the 1st operation gestalt (drawing 10) is explained. Throttle opening and valve timing are changed by S55. -O/L injection is started by S56. It judges whether throttle opening and valve timing were set as desired value (drawing 13 , 14) by S57. When the setup is not completed, jump-spark-ignition combustion is continued by setting jump spark ignition to ON by S58. When it is judged that a setup was completed by S57, jump spark ignition is turned off by S59, and compressed self-ignition combustion is started.

[0081] Subsequently, it judges whether it is a homogeneity calorific-capacity-of-combustion-chamber field based on drawing 15 by S60. In not being a homogeneity calorific-capacity-of-combustion-chamber field, it continues -O/L injection by S61. When judged as a homogeneity combustion zone, intake-stroke injection is started by S62, and compressed self-ignition combustion of a homogeneity condition is performed.

[0082] The control flow chart in the case of changing combustion from compressed self-ignition combustion to drawing 17 at jump-spark-ignition combustion is shown. Only a different place from the 1st operation gestalt (drawing 11) is explained. Throttle opening and valve timing are changed by S73. -O/L injection is started by S72. It judges whether a setup of throttle opening and valve timing was completed by S73.

[0083] When it is judged that the setup is not completed, while it has been off, compressed self-ignition combustion is continued [******] for jump spark ignition by S74. When it is judged that a setup was completed by S73, jump spark ignition is started [S75] by S76 by considering injection timing as compression stroke injection, and jump-spark-ignition combustion of a stratification condition is started.

[0084] Next, the 3rd operation gestalt of this invention is explained to details with reference to drawing 18 thru/or drawing 22 . Drawing 18 is system configuration drawing showing the configuration of the 3rd operation gestalt of the compressed self-ignition type gasoline engine concerning this invention. Also in this operation gestalt, it is dynamically switchable during engine operation in compressed self-ignition combustion and jump-spark-ignition combustion according to a service condition.

[0085] The engine 10 in drawing is equipped with the fuel injection equipment 17 and ignition plug 18 which inject a direct fuel in a suction port 11, the exhaust air port 12, the bis-ton 13, the intake valve 14, the exhaust air bulb 15, the crank angle sensor 16, and the cylinder.

[0086] The electronic control (it abbreviates to ECU hereafter) 1 which controls this engine 10 The combustion pattern judging section 2 which judges whether it operates according to a service condition by either combustion system of compressed self-ignition combustion and jump-spark-ignition combustion, The jump-spark-ignition combustion-control section 3 which controls the combustion parameter at the time of jump-spark-ignition combustion operation, The self-ignition combustion-control section 4 which controls the combustion-control parameter at the time of compressed self-

ignition combustion operation, It has the combustion change judging section 5 the change to compressed self-ignition combustion and jump-spark-ignition combustion judges [necessity or] whether it is unnecessary to be, and the combustion change control section 6 which controls combustion fuel injection timing, fuel oil consumption, and ignition timing, and realizes a smooth combustion change when a combustion change is required.

[0087] In addition, the combustion pattern judging section 2 which is the component of ECU1, the jump-spark-ignition combustion-control section 3, the self-ignition combustion-control section 4, the combustion change judging section 5, and the combustion change control section 6 are realized as a program of a microcomputer.

[0088] Moreover, based on the engine speed signal which the crank angle sensor 16 detected, and the accelerator opening signal (load) which the accelerator opening sensor (not shown) detected, ECU1 judges a service condition and judges a combustion pattern. Moreover, according to a service condition, fuel oil consumption, fuel injection timing, and ignition timing are computed. And based on this calculation result, a signal is sent to a fuel injection equipment 17 and an ignition plug 18.

[0089] Moreover, although not illustrated, the inhalation-of-air system which consists of the throttle valve for air content adjustment, the air flow meter for air content measurement, an air cleaner, and piping is prepared in the upstream of a suction port 11.

[0090] By ECU1, an inlet valve 14 and an exhaust valve 15 are considering a closing motion stage as a controllable configuration through the adjustable valve timing device 20 which is a closing motion stage adjustable means, control modification of a substantial compression ratio, the amount of EGR(s), etc. by an engine's load region in low, and are considering them as the configuration which can realize the elevated temperature in which self-ignition is possible, and a high-pressure condition near a compression top dead center, respectively.

[0091] Next, control of the closing motion timing of the ** and the exhaust valve in this operation gestalt is shown in drawing 19 . In the time of the usual jump-spark-ignition combustion, in near an exhaust air top dead center (TDC), it is made whenever [crank angle], and has from abundance the period of about about ten degrees, and the valve-opening polymerization period (overlap period) which both ** and an exhaust valve are opening. On the other hand, while reducing the exhaust air actuation angle at the time of compressed self-ignition combustion, the exhaust air valve-closing time term (henceforth EVC) was made into exhaust air TDC before, and the sealing period when both ** and an exhaust valve serve as close is established by controlling an inlet-valve open stage (henceforth IVO) after exhaust air TDC, while reducing an inhalation-of-air actuation angle.

[0092] As a device which makes adjustable the operating state of such a ** and an exhaust valve, there is an adjustable valve train system as shown, for example in JP,55-137305,A and JP,9-203307,A.

[0093] At the time of compressed self-ignition combustion, it makes it possible to make compressed self-ignition combustion with a gasoline engine generate, without heating inhalation of air and performing too much increment in a compression ratio by having established said sealing period, since elevated temperature exhaust gas can be shut up. Moreover, in this invention, the valve timing at the time of the above-mentioned compressed self-ignition combustion is used also for the jump-spark-ignition combustion in front of the change to the compressed self-ignition combustion from jump-spark-ignition combustion.

[0094] Next, drawing 20 explains the combustion stability over the air-fuel ratio (A/F) of compressed self-ignition combustion and jump-spark-ignition combustion in the throttle opening fixed conditions at the time of establishing the sealing period when both said ** and exhaust valve serve as close.

[0095] In compressed self-ignition combustion, a combustion stable zone is expandable to the Lean side (namely, low load side) of A/F by injecting some fuels [at least] at said sealing period. Since the fuel injected during the sealing period is compressed with self-EGR gas, this is because it changes reforming into the condition of it being exposed to an elevated temperature and a high-pressure field, reacting with the oxygen which exists in Self EGR, and being easy to carry out compressed self-ignition of the fuel.

[0096] Furthermore, since A/F is partially made as for a rich field to a combustion chamber in the thing which stratification-ize gaseous mixture and to perform by injecting some fuels [at least] to a

compression stroke at the time of compressed self-ignition combustion, the compressed self-ignition of A/F as the whole combustion chamber becomes possible also in the Lean condition.
[0097] the stratification in the same sealing period as said compressed self-ignition combustion, and the same throttle opening -- the dashed line of drawing 20 shows the jump-spark-ignition combustion stable zone in gaseous mixture. the stratification which compressed self-ignition combustion does not generate -- gaseous mixture -- even if it is a field, the field of A/F whose flame propagation combustion is attained by forming a flame nucleus by jump spark ignition exists.
[0098] Therefore, at said A/F region, shift becomes possible from jump-spark-ignition combustion to compressed self-ignition combustion by changing the injection timing of a fuel, though it is the same throttle opening, and the same ** and an exhaust valve closing motion stage as shown in the arrow head in drawing.
[0099] Next, the continuous line of drawing 21 explains the combustion change procedure which is to the base in this invention. The change to the compressed self-ignition combustion from jump-spark-ignition combustion is divided into two steps, and is carried out.
[0100] stratification Lean who made fuel-injection timing the compression stroke by injecting a fuel in an intake stroke in the 1st step from the jump-spark-ignition combustion in the homogeneity premixed air in a chemically correct mixture ratio while making throttle opening into size -- it shifts to the jump-spark-ignition combustion by gaseous mixture.
[0101] After shifting to stratification Lean combustion, it changes so that said sealing period of which the closing motion stage of ** and an exhaust valve is required by compressed self-ignition combustion may come. In order to compensate new **** to which a throttle decreases by the increment in the amount of self-EGR(s) at this time, it responds to said sealing period being extended, and opens to near the full open. It will be in the condition of - mark in drawing 20 in this condition.
[0102] In the 2nd step, it is the shift to the compressed self-ignition combustion from jump-spark-ignition combustion, and shift of combustion is carried out by changing the injection timing in the compression stroke in jump-spark-ignition combustion into the injection during said sealing period. Thereby, a combustion condition shifts to O mark from - mark of drawing 20 . The load effect at the time of a combustion change is absorbed by decreasing fuel oil consumption to coincidence. This is because there is the improvement effect of thermal efficiency since the combustion period is short compared with jump-spark-ignition combustion in compressed self-ignition combustion. Moreover, the discharge in an ignition plug may be stopped with the shift to compressed self-ignition combustion at this time.
[0103] Next, about a procedure in case the loads at the time of a combustion change differ to said primitive state, to said primitive state, the dashed line of drawing 21 explains the case of a low load, and the alternate long and short dash line of drawing 21 explains the case of a heavy load.
[0104] When a change load is low, in order to secure the combustion stability in jump-spark-ignition combustion, it becomes impossible to open throttle opening to the desired value in compressed self-ignition combustion. Although fuel-injection timing is carried out by changing into said sealing period like said primitive state in the shift to the compressed self-ignition combustion from jump-spark-ignition combustion at the time of a low load, in order to follow valve-opening actuation of a throttle on coincidence, compressed self-ignition combustion until an intake pressure goes up becomes unstable.
[0105] For the improvement in stability of compressed self-ignition combustion at this time, in addition to said sealing period injection which is the 1st fuel injection timing about the count of fuel injection, the compression stroke injection which is the 2nd fuel injection timing is added, and it may be 2 times. And stability is raised by fuel reforming by sealing period injection, and stratification-ization by compression stroke injection.
[0106] the shift to ** mark from - mark [in / in the change of this injection timing / drawing 20] -- it can catch -- the addition of said compression stroke injection -- gaseous mixture rich to a combustion chamber -- since a field is formed, it uses becoming easy to generate compressed self-ignition combustion.
[0107] By making it increase to the total injection quantity in the time of throttle valve-opening

actuation being completed, the total injection quantity of the fuel immediately after a combustion change can acquire improvement in combustion stability, and the reduction effect of the torque fluctuation at the time of a combustion change.
[0108] Moreover, in the jump-spark-ignition combustion in front of the combustion change to the compressed self-ignition combustion from jump-spark-ignition combustion, by carrying out the lag of the discharge timing in an ignition plug, since it becomes possible to make HC in the middle of oxidation reaction remain mostly in self-EGR gas while raising the temperature of self-EGR gas, the compressed self-ignition combustion immediately after a combustion change can be generated certainly.

[0109] Furthermore, since the reforming effect of a fuel increases by discharging from an ignition plug near before [TDC] 30 degree at the time of compressed self-ignition combustion, the improvement in stability of compressed self-ignition combustion at the time of a combustion change can be obtained.
[0110] If whole-quantity injection of the fuel is carried out at said sealing period at the time of a heavy load, the calorific value in exhaust air TDC becomes excessive, and with aggravation of fuel consumption, the detonation of compressed self-ignition combustion will occur and it will be knocking. Therefore, in a heavy load side, while decreasing the fuel oil consumption of said sealing period to a primitive state, it prevents that make injection of a fuel into 2 times in said sealing period and an intake stroke, and reforming of the fuel is carried out too much.
[0111] A difference of the fuel injection timing in the combustion change procedure to three kinds of loads at the time of a heavy load and the sealing stage of said ** and exhaust valve is shown in drawing 22 at the time of the primitive state described above and a low load. However, the suitable load range of a change does not necessarily need to perform three kinds of changes in the same engine in order to receive the effect of **, such as an engine's base compression ratio, an inhalation air content, etc.
[0112] Moreover, since the combustion change to the compressed self-ignition combustion from the jump-spark-ignition combustion by this invention is carried out by modification of the injection timing of the fuel injection valve for every gas column, it is easy to change a combustion change stage for every gas column. Therefore, it is possible to reduce the engine torque fluctuation at the time of the combustion change to the compressed self-ignition combustion from jump-spark-ignition combustion by changing injection timing one by one for every gas column and every gas column group.

[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1] He is the compressed-self-ignition type gasoline engine which does starting compressed-self-ignition combustion as the feature after performing jump-spark-ignition combustion in a stratification condition that jump-spark-ignition combustion performs fuel injection into a compression stroke, in a compressed-self-ignition type gasoline engine which equips a combustion chamber with an injection valve in a cylinder which injects a direct fuel, and changes dynamically jump-spark-ignition combustion and compressed-self-ignition combustion by service condition, in case a combustion change is carried out to compressed-self-ignition combustion operation from jump-spark-ignition combustion operation.
[Claim 2] He is the compressed self-ignition type gasoline engine according to claim 1 characterized by performing jump-spark-ignition combustion in a stratification condition that jump-spark-ignition combustion performs fuel injection into a compression stroke first in case a combustion change is carried out to jump-spark-ignition combustion operation from compressed self-ignition combustion operation.
[Claim 3] He is the compressed self-ignition type gasoline engine characterized by performing compressed self-ignition combustion in a stratification condition that compressed self-ignition combustion performs fuel injection into a compression stroke first in case a combustion change is carried out to compressed self-ignition combustion operation from jump-spark-ignition combustion operation in a compressed self-ignition type gasoline engine which equips a combustion chamber with an injection valve in a cylinder which injects a direct fuel, and changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by service condition.
[Claim 4] A compressed self-ignition type gasoline engine according to claim 3 characterized by performing jump-spark-ignition combustion after performing compressed self-ignition combustion in a stratification condition of performing fuel injection into a compression stroke at the time of compressed self-ignition combustion, in case a combustion change is carried out to jump-spark-ignition combustion operation from compressed self-ignition combustion operation.
[Claim 5] In a compressed self-ignition type gasoline engine which equips a combustion chamber with a closing motion stage adjustable means to change the closing motion stage of an injection valve in a cylinder, and an induction-exhaust valve to inject a direct fuel, and changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by service condition In case it changes from jump-spark-ignition combustion to compressed self-ignition combustion, a sealing period which both induction-exhaust valves closed near the compression top dead center with said closing motion stage adjustable means is established. Compressed self-ignition combustion is a compressed self-ignition type gasoline engine first characterized by performing compressed self-ignition combustion which performs fuel injection during said sealing period.
[Claim 6] A compressed self-ignition type gasoline engine according to claim 5 characterized by performing jump-spark-ignition combustion after performing compressed self-ignition combustion which performs fuel injection during said sealing period, in case it changes from compressed self-ignition combustion to jump-spark-ignition combustion.

[Claim 7] In a compressed self-ignition type gasoline engine which equips a combustion chamber with an injection valve in a cylinder which injects a direct fuel, and changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by service condition In case a combustion change is carried out to compressed self-ignition combustion operation from jump-spark-ignition combustion operation He is the compressed self-ignition type gasoline engine which starts compressed self-ignition combustion and is characterized by compressed self-ignition combustion performing compressed self-ignition combustion in a stratification condition of performing fuel injection into a compression stroke first after performing jump-spark-ignition combustion in a stratification condition that jump-spark-ignition combustion performs fuel injection into a compression stroke.
[Claim 8] He is the compressed self-ignition type gasoline engine according to claim 7 which does as the feature that start jump-spark-ignition combustion and jump-spark-ignition combustion performs jump-spark-ignition combustion in a stratification condition of performing fuel injection into a compression stroke first after performing compressed self-ignition combustion in a stratification condition that compressed self-ignition combustion performs fuel injection into a compression stroke, in case a combustion change is carried out to compressed self-ignition combustion operation from compressed self-ignition combustion operation.
[Claim 9] In a compressed self-ignition type gasoline engine which equips a combustion chamber with a closing motion stage adjustable means to change the closing motion stage of an injection valve in a cylinder, and an induction-exhaust valve to inject a direct fuel, and changes dynamically jump-spark-ignition combustion and compressed self-ignition combustion by service condition In case it changes from jump-spark-ignition combustion to compressed self-ignition combustion, a sealing period which both induction-exhaust valves closed near the compression top dead center with said closing motion stage adjustable means is established. He is the compressed self-ignition type gasoline engine which starts compressed self-ignition combustion and is characterized by compressed self-ignition combustion performing compressed self-ignition combustion which performs fuel injection during said sealing period first after performing jump-spark-ignition combustion in a stratification condition of performing fuel injection into a compression stroke.
[Claim 10] He is the compressed self-ignition type gasoline engine according to claim 9 characterized by performing jump-spark-ignition combustion and jump-spark-ignition combustion performing jump-spark-ignition combustion in a stratification condition of performing fuel injection into a compression stroke first after performing compressed self-ignition combustion to which compressed self-ignition combustion carries out fuel injection during said sealing period, in case it changes from compressed self-ignition combustion to jump-spark-ignition combustion.
[Claim 11] Ignition timing in front of a change to compressed self-ignition combustion from said jump-spark-ignition combustion is a compressed self-ignition type gasoline engine given in any 1 term of claims 1, 3, 5, 7, and 9 characterized by carrying out a lag to ignition timing of a steady state in the same engine rotational frequency and the same load conditions.
[Claim 12] A compressed self-ignition type gasoline engine according to claim 11 characterized by discharging from said jump-spark-ignition combustion to an ignition plug to compressed self-ignition combustion after a change and near before [a compression top dead center] 30 degree, promoting compressed self-ignition, and stopping jump spark ignition after initiation of compressed self-ignition combustion.
[Claim 13] A compressed self-ignition type gasoline engine according to claim 5 or 9 characterized by injecting the remainder of a fuel in a compression stroke or an intake stroke according to an engine's load at the time of a change to compressed self-ignition combustion from said jump-spark-ignition combustion while injecting some fuels during said sealing period.
[Claim 14] A compressed self-ignition type gasoline engine according to claim 13 characterized by increasing the quantity of fuel quantity injected during said sealing period to the time of the usual compressed self-ignition combustion at the time of a change to compressed self-ignition combustion from said jump-spark-ignition combustion.
[Claim 15] He is a compressed self-ignition type gasoline engine given in any 1 term of claims 5, 9, 11,

12, 13, and 14 which a low load side considers the length of said sealing period as abbreviation regularity according to a load at the time of a combustion change at the time of a change to compressed self-ignition combustion from said jump-spark-ignition combustion, and are characterized by decreasing the length of said sealing period according to an increment in a load from a place beyond a predetermined load.
[Claim 16] A compressed self-ignition type gasoline engine of claim 1 characterized by dividing into at least two or more groups a gas column which performs a combustion change, shifting time amount among groups, and changing sequential combustion at the time of a change to compressed self-ignition combustion from said jump-spark-ignition combustion thru/or claim 15 given in any 1 term.

[Translation done.]

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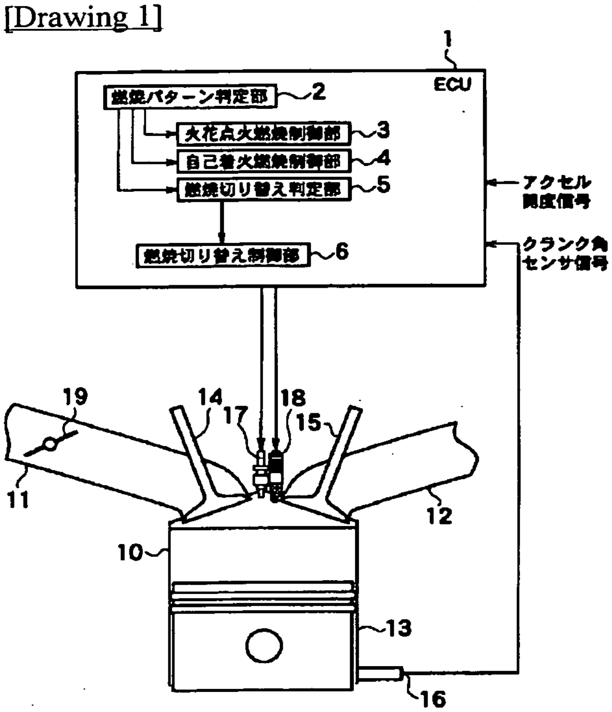
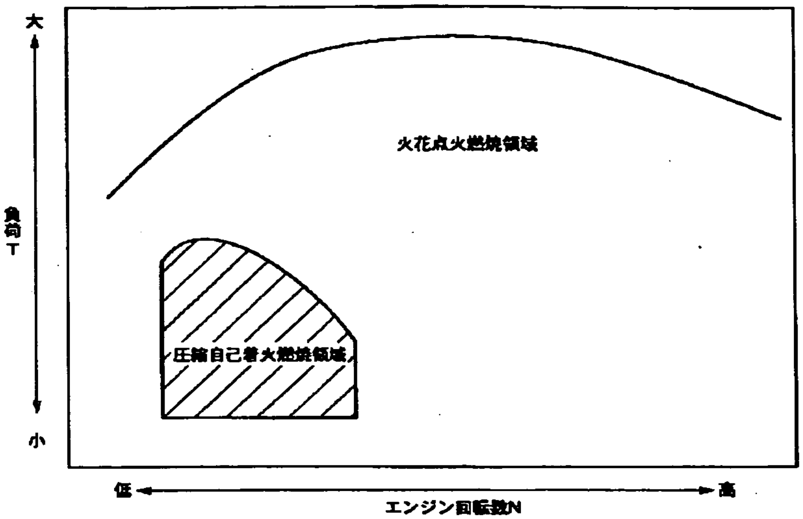
DRAWINGS

[Drawing 1]



[Drawing 2]



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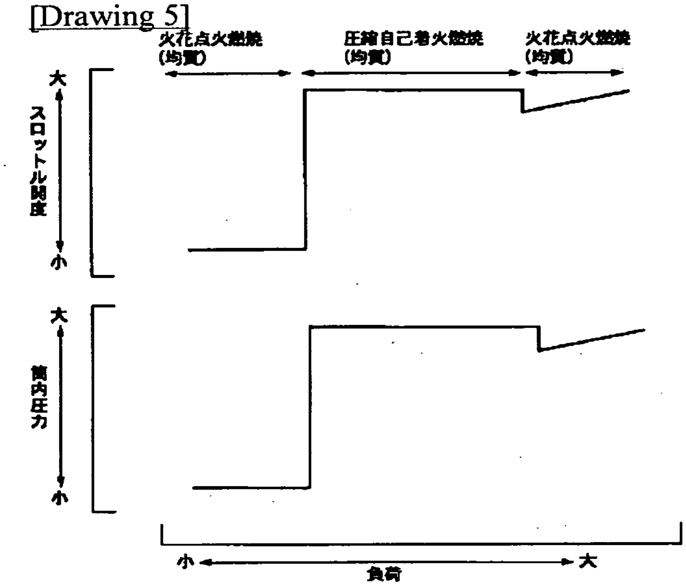
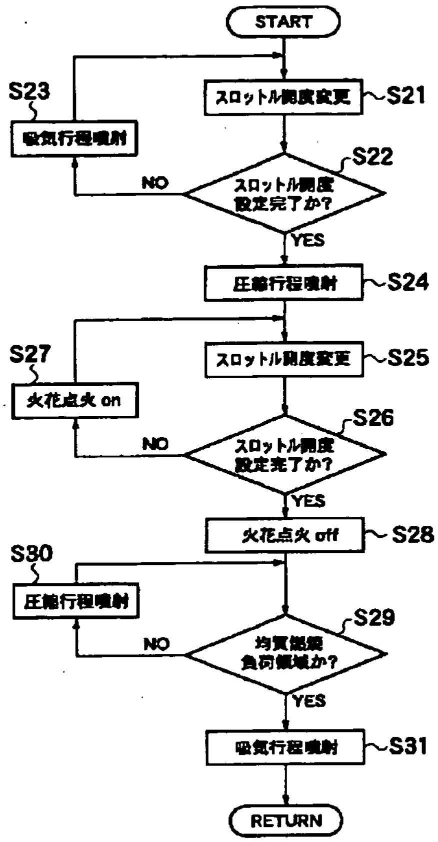


[Drawing 10]



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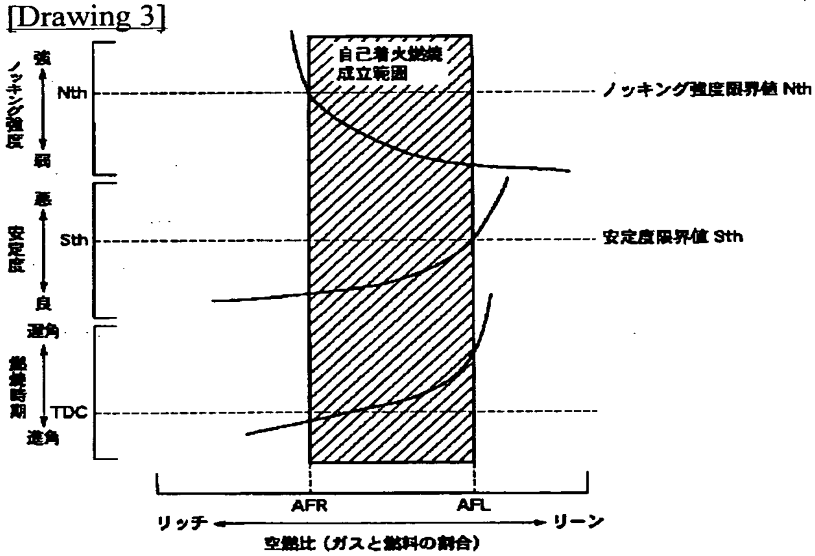

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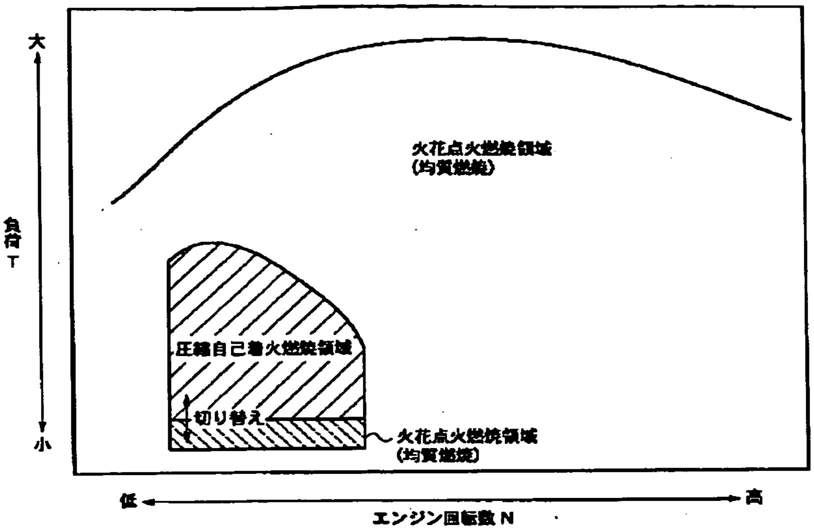

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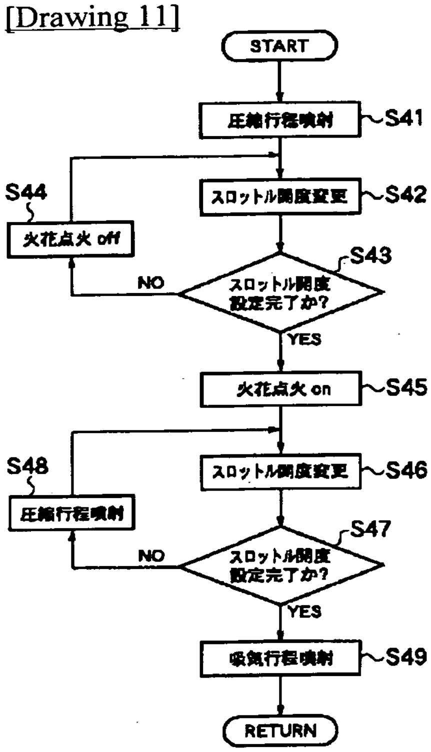
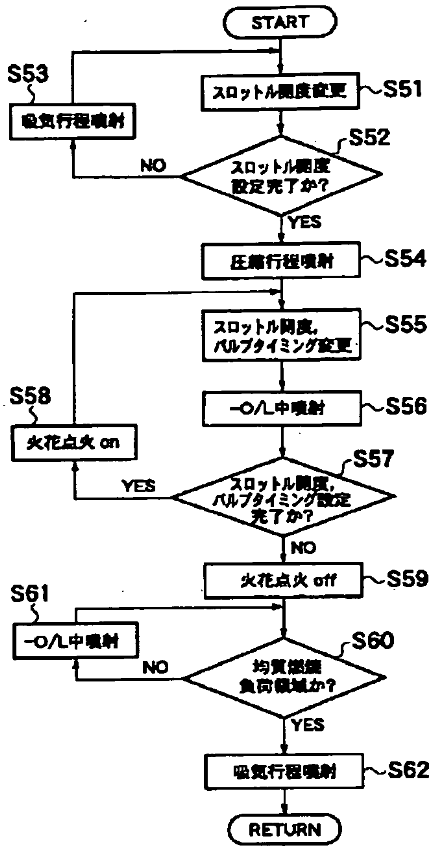
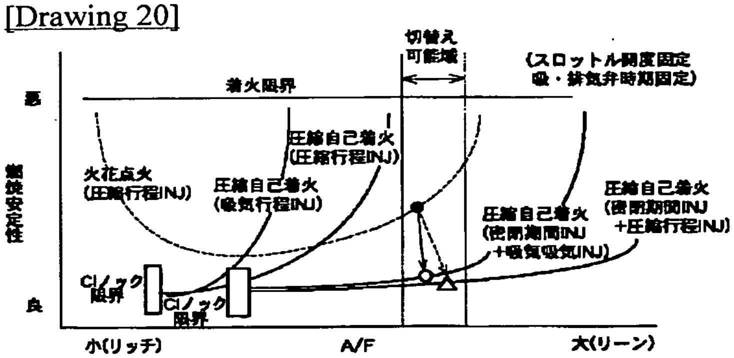


[Drawing 16]



[Drawing 20]



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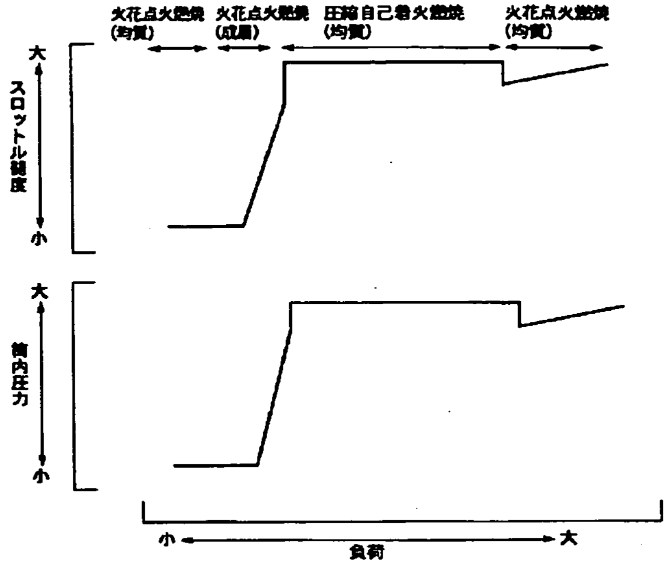
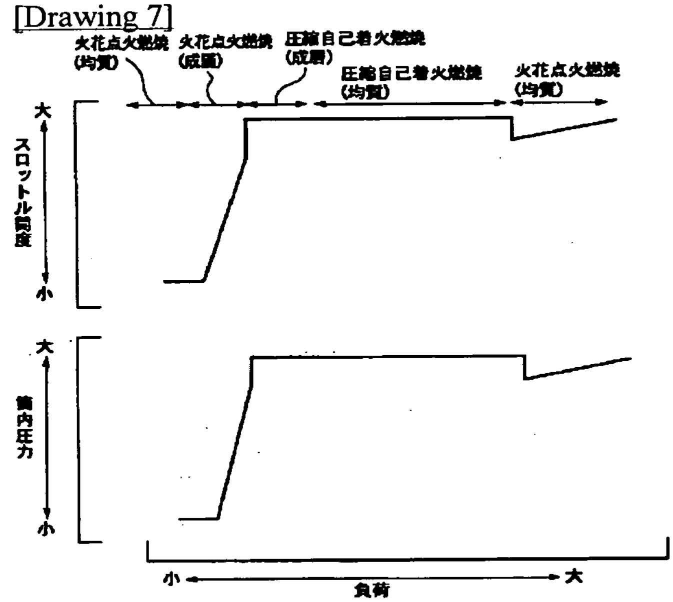
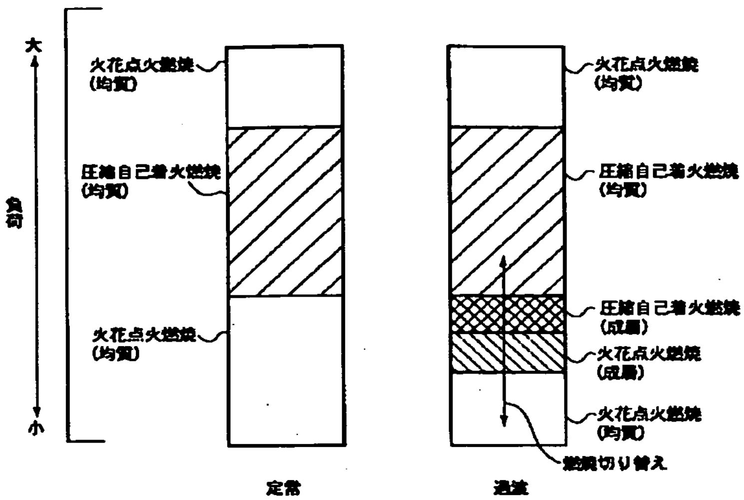


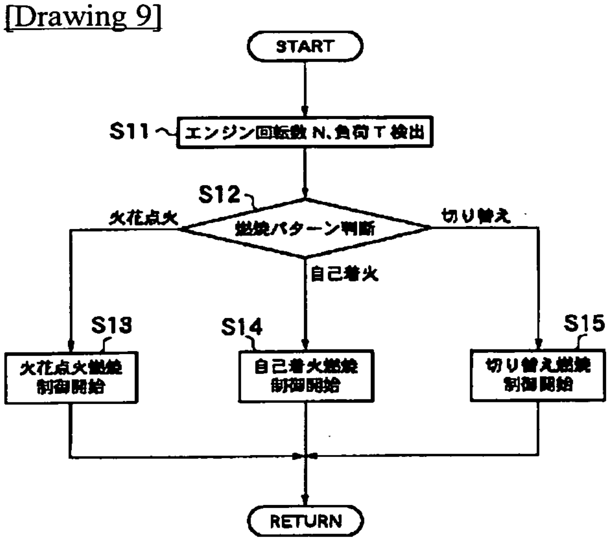
[Drawing 7]



[Drawing 8]



[Drawing 9]



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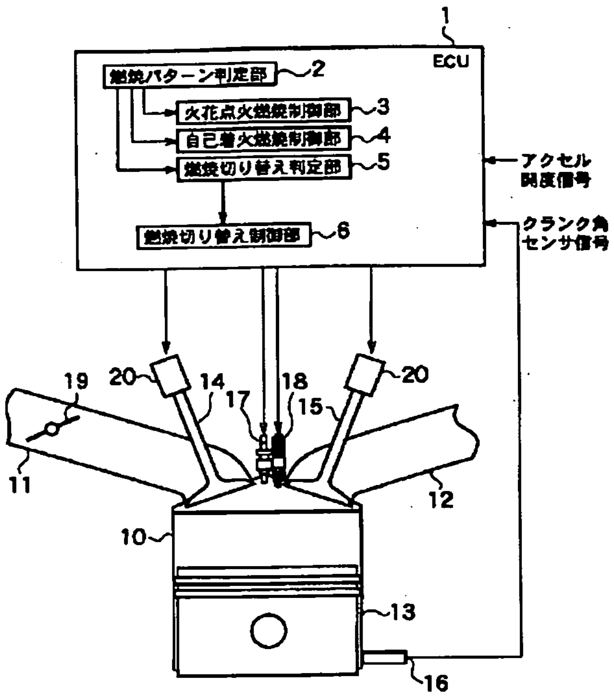
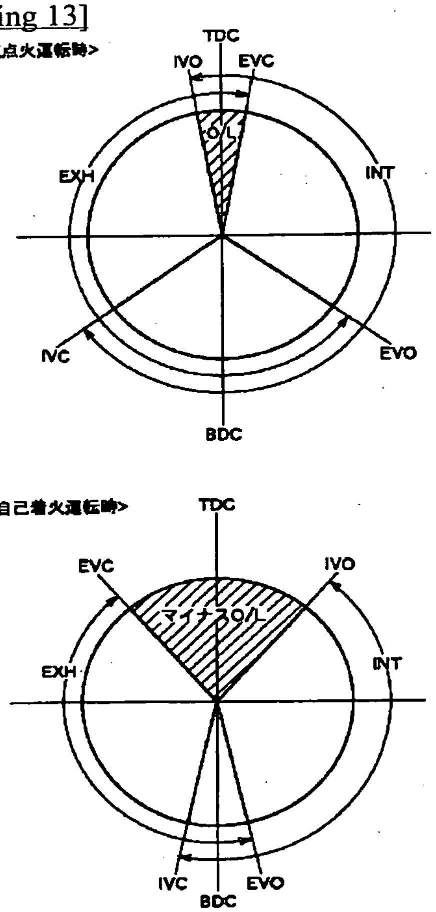


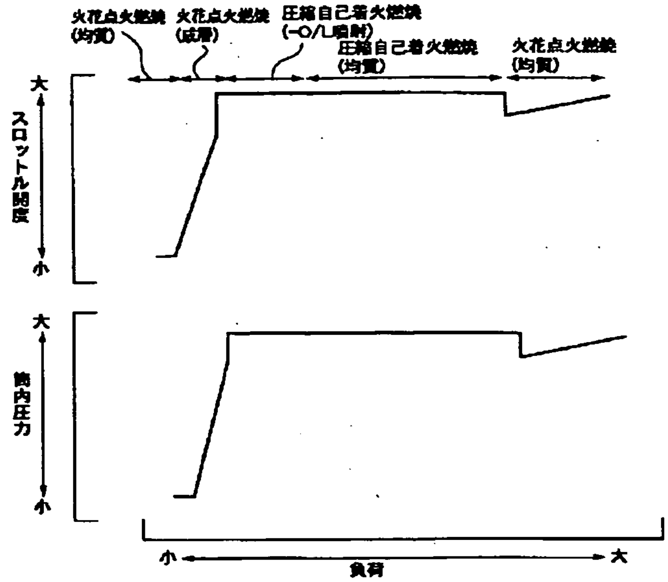
[Drawing 13]

(a) <火花点火運転時>

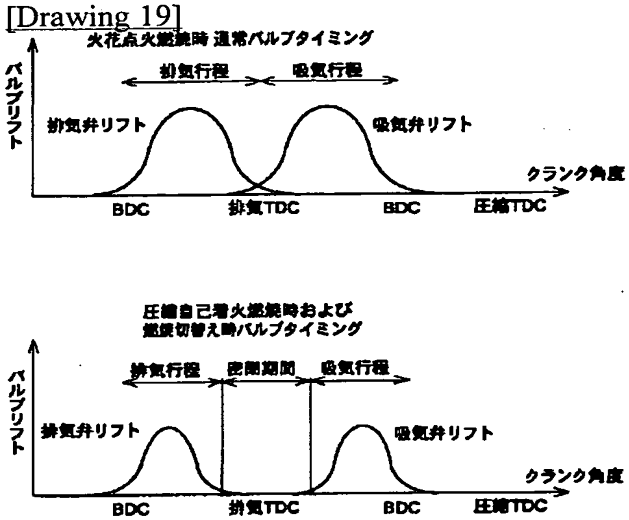
(b) <圧縮自己着火運転時>



[Drawing 14]



[Drawing 19]



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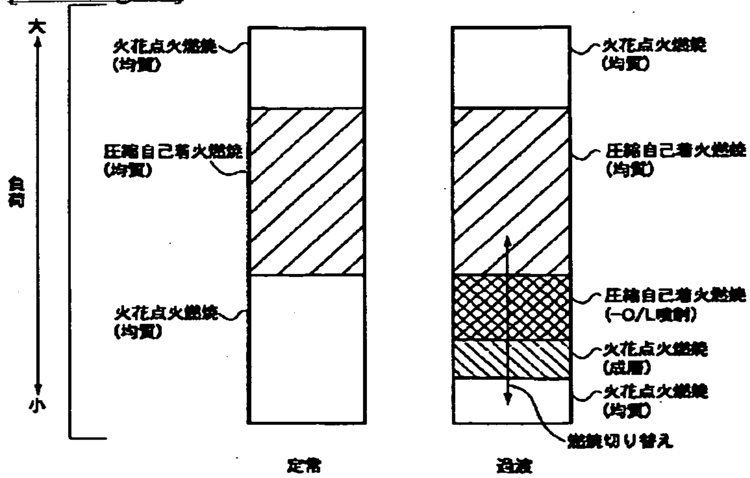
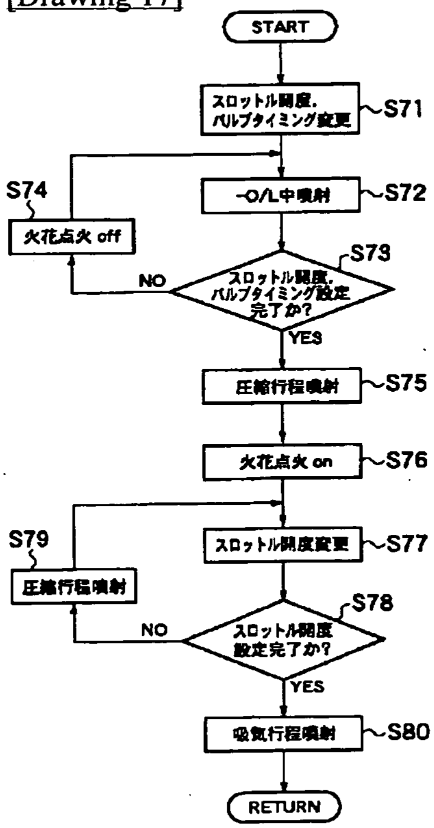


[Drawing 17]



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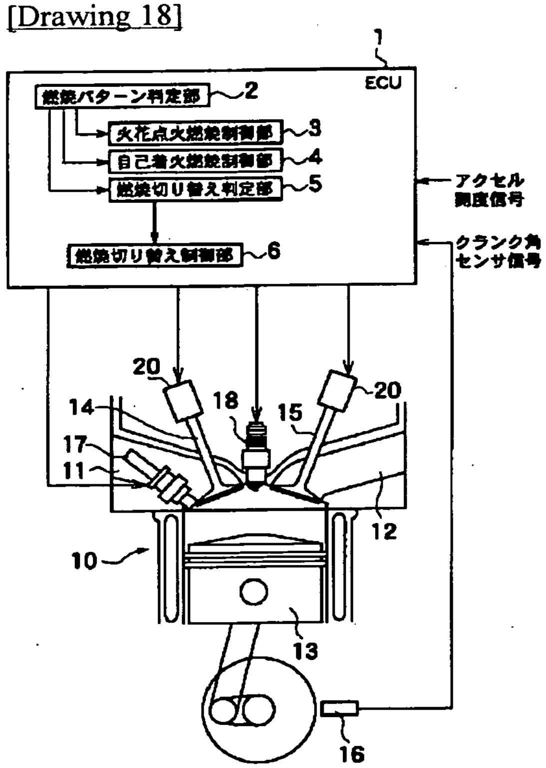
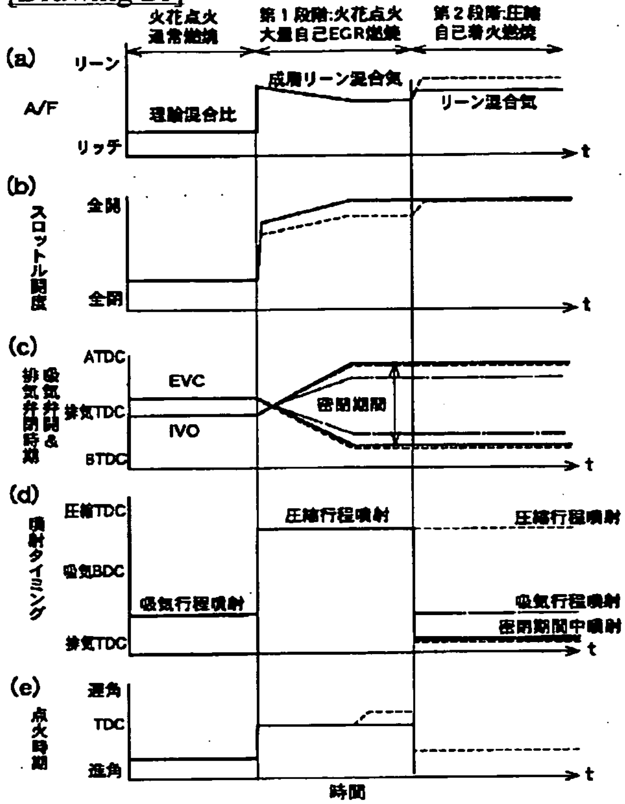
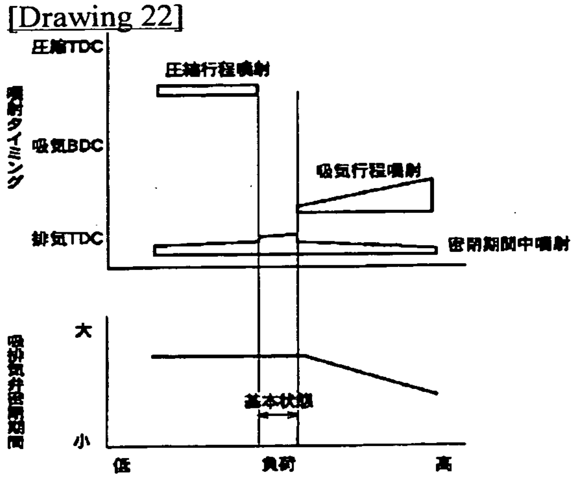


[Drawing 21]



[Drawing 22]



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